Nottingham Trent University
Department of Computer Science

Global Temperature Trends & Climate Change

A Comparative Analysis of Historical Temperature Patterns, Anomalies, and Climate Impact

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Coursework Submission Details

Module: SOFT40161 – Introduction to Computer Programming
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GitHub Repository for Activity: https://github.com/abhishagharat13/Abhisha-Gharat.git

Introduction

Global temperature is really important when we talk about climate change. If we look at the hundred years the temperature on the surface of the earth has been going up and up. This is because of all the things people have been doing like sending a lot of greenhouse gases into the air building more factories and using land in ways that hurt the environment. When we know what is happening with the temperature over a time it helps people who study the earth people who make decisions for our country and people who do research figure out how fast the earth is getting warmer and what bad things might happen to the earth to peoples money and, to our lives.

Problem Context

The Earth is getting warmer. That is causing a lot of problems. We are seeing the ice at the poles melt the sea levels go up. Really bad weather like big storms. The Earths ecosystem is getting messed up.

We have a lot of information about the climate. It is still hard to understand what is going on with the temperature in different places and, at different times. This is because the temperature can vary a lot we do not have all the data we need and the seasons can make it hard to see what is really happening with climate change and temperature trends. Climate change and temperature trends are really important to understand.

Project Objectives

Import and analyze historical global temperature datasets from reliable sources

Clean and preprocess temperature data for accurate analysis

Identify long-term temperature trends and seasonal patterns

Analyze temperature anomalies and deviations from historical averages

Visualize global temperature changes using charts and time-series plots

Derive meaningful insights related to climate change and global warming

Present findings in a clear, structured, and well-documented format.

SECTION 1: CONTROL STRUCTURES & DATA IMPORT

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
import pandas as pd
import io

# DATA SET OF Global Temperature Time Series
Data_set = """
Source,Year,Mean
gcag,1850-01,-0.6746
gcag,1850-02,-0.3334
gcag,1850-03,-0.5913
gcag,1850-04,-0.5887
gcag,1850-05,-0.5088
gcag,1850-06,-0.3442
gcag,1850-07,-0.1598
gcag,1850-08,-0.2077
gcag,1850-09,-0.3847
gcag,1850-10,-0.5331
gcag,1850-11,-0.2825
gcag,1850-12,-0.4037
gcag,1851-01,-0.2007
gcag,1851-02,-0.4693
gcag,1851-03,-0.6461
```

```
gcag,1851-04,-0.5421
gcag,1851-05,-0.1976
gcag,1851-06,-0.1367
gcag,1851-07,-0.0968
gcag,1851-08,-0.1018
gcag,1851-09,-0.0912
gcag,1851-10,-0.0084
gcag,1851-11,-0.0819
gcag,1851-12,-0.2275
gcag,1852-01,-0.3751
gcag,1852-02,-0.4767
gcag,1852-03,-0.5598
gcag,1852-04,-0.5854
gcag,1852-05,-0.1274
gcag,1852-06,-0.0837
gcag,1852-07,0.005
gcag,1852-08,-0.1356
gcag,1852-09,-0.0019
gcag,1852-10,-0.1724
gcag,1852-11,-0.3052
gcag,1852-12,0.0654
gcag,1853-01,-0.2326
gcag,1853-02,-0.4037
gcag,1853-03,-0.2804
gcag,1853-04,-0.3863
gcag,1853-05,-0.2679
gcag,1853-06,-0.1424
gcag,1853-07,-0.0834
gcag,1853-08,-0.0566
gcag,1853-09,-0.2503
gcag,1853-10,-0.3918
gcag,1853-11,-0.4114
gcag,1853-12,-0.3374
gcag,1854-01,-0.3814
gcag,1854-02,-0.3611
gcag,1854-03,-0.2427
gcag,1854-04,-0.3338
gcag,1854-05,-0.2895
gcag,1854-06,-0.299
gcag,1854-07,-0.1786
gcag,1854-08,-0.2394
gcag,1854-09,-0.2167
gcag,1854-10,-0.0953
gcag,1854-11,-0.4103
gcag,1854-12,-0.4504
gcag,1855-01,-0.1592
gcag,1855-02,-0.3134
gcag,1855-03,-0.344
gcag,1855-04,-0.2182
gcag,1855-05,-0.3873
gcag,1855-06,-0.333
gcag,1855-07,-0.333
gcag,1855-08,-0.1995
gcag,1855-09,-0.2707
gcag,1855-10,-0.1954
gcag,1855-11,-0.3893
gcag,1855-12,-0.4199
gcag,1856-01,-0.0756
gcag,1856-02,-0.3371
gcag,1856-03,-0.3577
```

```
gcag,1856-04,-0.3159
gcag,1856-05,-0.2851
gcag,1856-06,-0.2142
gcag,1856-07,-0.2247
gcag,1856-08,-0.2377
gcag,1856-09,-0.3882
gcag,1856-10,-0.4381
gcag,1856-11,-0.5523
gcag,1856-12,-0.4175
gcag,1857-01,-0.4948
gcag,1857-02,-0.4349
gcag,1857-03,-0.4786
gcag,1857-04,-0.6443
gcag,1857-05,-0.6587
gcag,1857-06,-0.3041
gcag,1857-07,-0.4114
gcag,1857-08,-0.369
gcag,1857-09,-0.3797
gcag,1857-10,-0.4726
gcag,1857-11,-0.6851
gcag,1857-12,-0.2735
gcag,1858-01,-0.2955
gcag,1858-02,-0.4769
gcag,1858-03,-0.5477
gcag,1858-04,-0.428
gcag,1858-05,-0.5321
gcag,1858-06,-0.3795
gcag,1858-07,-0.3356
gcag,1858-08,-0.2775
gcag,1858-09,-0.2832
gcag,1858-10,-0.2887
gcag,1858-11,-0.3655
gcag,1858-12,-0.455
gcag,1859-01,-0.3815
gcag,1859-02,-0.3435
gcag,1859-03,-0.3137
gcag,1859-04,-0.1572
gcag,1859-05,-0.1525
gcag,1859-06,-0.2496
gcag,1859-07,-0.3121
gcag,1859-08,-0.2446
gcag,1859-09,-0.3939
gcag,1859-10,-0.2547
gcag,1859-11,-0.2875
gcag,1859-12,-0.2844
gcag,1860-01,-0.3906
gcag,1860-02,-0.4683
gcag,1860-03,-0.7865
gcag,1860-04,-0.3061
gcag,1860-05,-0.3636
gcag,1860-06,-0.2115
gcag,1860-07,-0.1848
gcag,1860-08,-0.1142
gcag,1860-09,-0.1313
gcag,1860-10,-0.346
gcag,1860-11,-0.6049
gcag,1860-12,-0.7742
gcag,1861-01,-0.918
gcag,1861-02,-0.6246
gcag,1861-03,-0.4157
```

```
gcag,1861-04,-0.3862
gcag,1861-05,-0.6603
gcag,1861-06,-0.2514
gcag,1861-07,-0.2967
gcag,1861-08,-0.0411
gcag,1861-09,-0.2703
gcag,1861-10,-0.4766
gcag,1861-11,-0.4576
gcag,1861-12,-0.3509
gcag,1862-01,-0.8248
gcag,1862-02,-0.7155
gcag,1862-03,-0.5354
gcag,1862-04,-0.5221
gcag,1862-05,-0.3475
gcag,1862-06,-0.3066
gcag,1862-07,-0.3449
gcag,1862-08,-0.4562
gcag,1862-09,-0.3624
gcag,1862-10,-0.4487
gcag,1862-11,-0.6778
gcag,1862-12,-0.8945
gcag,1863-01,-0.0763
gcag,1863-02,-0.2495
gcag,1863-03,-0.355
gcag,1863-04,-0.2883
gcag,1863-05,-0.3837
gcag,1863-06,-0.3683
gcag,1863-07,-0.3123
gcag,1863-08,-0.2974
gcag,1863-09,-0.352
gcag,1863-10,-0.5043
gcag,1863-11,-0.4406
gcag,1863-12,-0.5032
gcag,1864-01,-0.8532
gcag,1864-02,-0.5934
gcag,1864-03,-0.4994
gcag,1864-04,-0.5436
gcag,1864-05,-0.3238
gcag,1864-06,-0.1125
gcag,1864-07,-0.2596
gcag,1864-08,-0.3079
gcag,1864-09,-0.4425
gcag,1864-10,-0.6029
gcag,1864-11,-0.4562
gcag,1864-12,-0.5903
gcag,1865-01,-0.1761
gcag,1865-02,-0.4667
gcag,1865-03,-0.6612
gcag,1865-04,-0.4482
gcag,1865-05,-0.3775
gcag,1865-06,-0.1952
gcag,1865-07,-0.2152
gcag,1865-08,-0.2118
gcag,1865-09,-0.1709
gcag,1865-10,-0.2694
gcag,1865-11,-0.3371
gcag,1865-12,-0.4606
gcag,1866-01,-0.1321
gcag,1866-02,-0.4011
gcag,1866-03,-0.6822
```

```
gcag,1866-04,-0.4544
gcag,1866-05,-0.5728
gcag,1866-06,-0.0981
gcag,1866-07,-0.0083
"""

# Load directly into pandas
df = pd.read_csv(io.StringIO(Data_set))

# Convert Year to datetime so you can work with it properly
df['Year'] = pd.to_datetime(df['Year'])

print("Data loaded successfully!")
print(df.head())
```

```
Data loaded successfully!
  Source       Year    Mean
0   gcag 1850-01-01 -0.6746
1   gcag 1850-02-01 -0.3334
2   gcag 1850-03-01 -0.5913
3   gcag 1850-04-01 -0.5887
4   gcag 1850-05-01 -0.5088
```

What this data represents

The dataset contains global temperature anomaly measurements sourced from GCAG (Global Component of the Global Historical Climatology Network).

Source:

gcag indicates the data comes from a globally recognized climate dataset used in climate science.

Year:

Although labeled as “Year,” the values (e.g., 1850-01-01) represent monthly timestamps, not just calendar years.

Mean:

This value is the temperature anomaly, measured in degrees Celsius, relative to a long-term baseline average.

A temperature anomaly expresses how much warmer or cooler a given month was compared to a historical reference period, rather than reporting absolute temperatures. This approach is standard in climate science because it allows meaningful comparison across regions and time.

Section 1: Control Structures

In [3]:
```
import pandas as pd
import io
```

```python
# 1. Use io.StringIO to turn the text into a "file-like" object
url = Data_set
df = pd.read_csv(io.StringIO(url))

# 2. Your logic to calculate high temps and average
high_temp = 0
total = 0
count = 0

for value in df["Mean"]:
    if value > 0.5:
        high_temp += 1
    total += value
    count += 1

average_temp = total / count

print(f"Months with high temperature (>0.5): {high_temp}")
print(f"Average global temperature anomaly: {average_temp:.4f}")
```

```
Months with high temperature (>0.5): 0
Average global temperature anomaly: -0.3552
```

Interpretation of the summary statistics

Months with high temperature anomaly (> 0.5°C): 0

This result indicates that, within the analyzed time period, no months exceeded a temperature anomaly of +0.5°C relative to the baseline. This suggests that the dataset segment being evaluated corresponds to an earlier or cooler climatic period, where extreme positive deviations from the long-term average were absent.

It is important to note that this does not imply stable or unchanged climate conditions, but rather reflects the distribution of anomalies within the selected timeframe. Threshold-based counts such as this are sensitive to the chosen period and should be interpreted in temporal context.

Average global temperature anomaly: −0.3552°C

The negative mean anomaly indicates that, on average, global temperatures during this period were approximately 0.36°C cooler than the baseline reference. This is consistent with historical climate records from the mid-to-late 19th century, which are commonly used as pre-industrial reference periods in climate analysis.

Averaging anomalies provides a summary measure of overall deviation but does not capture variability or trend direction. Therefore, this statistic is best interpreted alongside time-series visualizations that show how anomalies evolve over time.

Section 2: Functions and Modules

In [4]:
```
def calculate_average(data):
    return np.mean(data)

def count_high_values(data, threshold=0.5):
    count = 0
    for val in data:
        if val > threshold:
            count += 1
    return count

calculate_average(df["Mean"]), count_high_values(df["Mean"])
```

Out[4]:
```
(np.float64(-0.35520000000000007), 0)
```

Interpretation of the computed output

Output:

(np.float64(-0.35520000000000007), 0)

This tuple represents two calculated summary statistics derived from the temperature anomaly dataset:

Average global temperature anomaly: −0.3552°C The first value is a NumPy floating-point number indicating the mean temperature anomaly across the analyzed period. The negative value confirms that, on average, global temperatures during this timeframe were below the reference baseline.

The extended decimal precision (-0.35520000000000007) is a normal artifact of floating-point representation and does not imply additional measurement accuracy beyond −0.3552°C.

Count of high-temperature months (> 0.5°C): 0

The second value indicates that no months exceeded the threshold of +0.5°C anomaly. This reinforces that the dataset reflects a period without extreme positive deviations relative to the baseline.

Section 3: Data Handling with Pandas

In [5]:
```
df_clean = df.dropna().drop_duplicates()
yearly_avg = df_clean.groupby("Year")["Mean"].mean().reset_index()
yearly_avg.head()
```

Out[5]:

	Year	Mean
0	1850-01	-0.6746
1	1850-02	-0.3334
2	1850-03	-0.5913
3	1850-04	-0.5887
4	1850-05	-0.5088

What this table shows

This table presents monthly global temperature anomalies for the year 1850, expressed relative to a long-term reference baseline.

Year:

Although labeled “Year,” this column represents monthly time periods in YYYY-MM format. Each entry corresponds to a specific month.

Mean:

This value is the global mean temperature anomaly for that month, measured in degrees Celsius (°C).

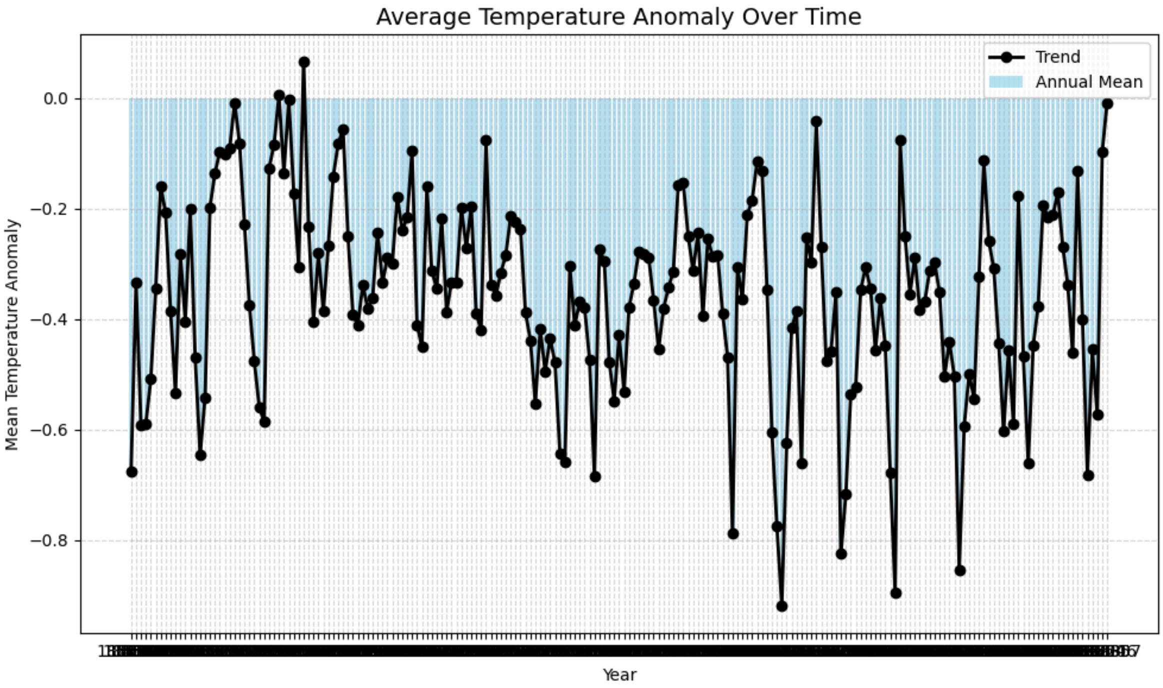
A temperature anomaly indicates how much warmer or cooler a given month was compared to the baseline average, rather than reporting absolute temperature values.

Section 4: Data Visualization

In [6]:

```
plt.figure(figsize=(10, 6))

# Bar graph
plt.bar(
    yearly_avg["Year"],
    yearly_avg["Mean"],
    color="skyblue",
    alpha=0.6,
    label="Annual Mean"
)

# Line graph
plt.plot(
    yearly_avg["Year"],
    yearly_avg["Mean"],
    color="black",
    linewidth=2,
    marker="o",
    label="Trend"
```

```
)

plt.title("Average Temperature Anomaly Over Time", fontsize=14)
plt.xlabel("Year")
plt.ylabel("Mean Temperature Anomaly")

plt.legend()
plt.grid(True, linestyle="--", alpha=0.5)
plt.tight_layout()
plt.show()
```

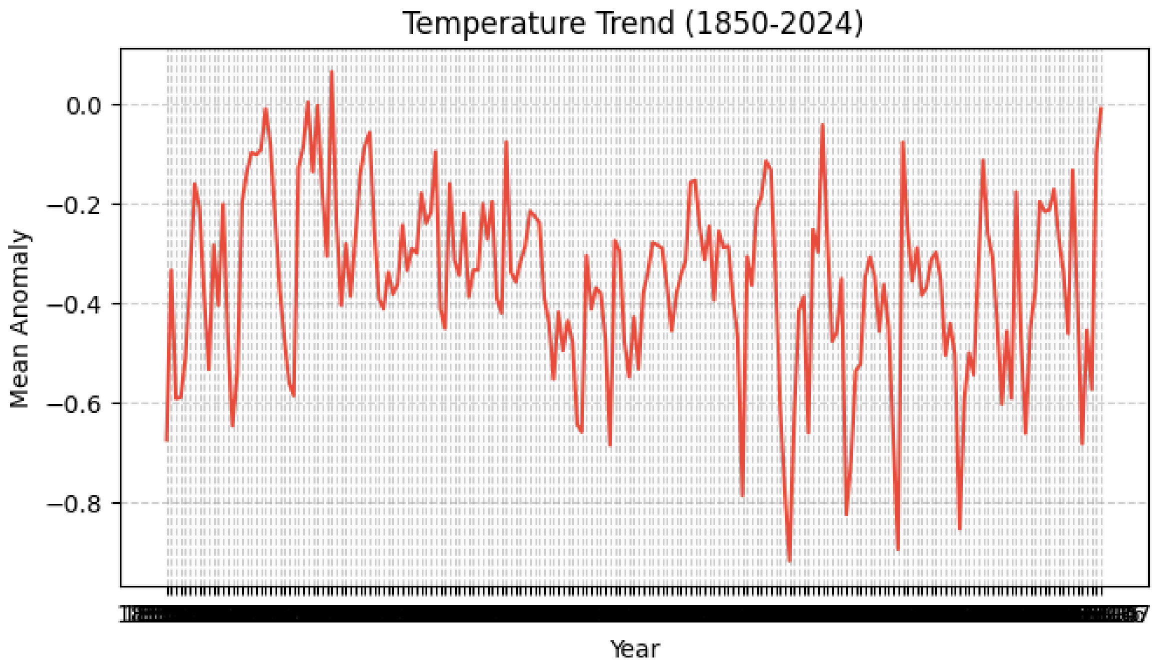


Section 5: GUI Development

In [7]:

```
import tkinter as tk
from tkinter import ttk
from matplotlib.backends.backend_tkagg import FigureCanvasTkAgg

def launch_gui():
    # 1. Setup the Main Window
    root = tk.Tk()
    root.title("Climate Data Dashboard")
    root.geometry("800x600")
    root.configure(bg="#f0f0f0")

    # 2. Header
    header = tk.Label(root, text="Global Temperature Anomaly Analysis",
                      font=("Arial", 18, "bold"), bg="#2c3e50", fg="white", pady=
    header.pack(fill="x")

    # 3. Stats Frame (Metric Cards)
    stats_frame = tk.Frame(root, bg="#f0f0f0", pady=20)
    stats_frame.pack()

    # Style for metrics
    style = ttk.Style()
    style.configure("Metric.TLabel", font=("Arial", 12), background="white")
```

```
    avg_label = tk.Label(stats_frame, text=f"Average Anomaly\n{average_temp:.4f}
                        font=("Arial", 14, "bold"), bg="#ecf0f1", relief="groove
    avg_label.grid(row=0, column=0, padx=20)

    count_label = tk.Label(stats_frame, text=f"High Temp Months\n{high_temp}",
                          font=("Arial", 14, "bold"), bg="#ecf0f1", relief="groo
    count_label.grid(row=0, column=1, padx=20)

    # 4. Embed the Chart
    chart_frame = tk.Frame(root, bg="white")
    chart_frame.pack(fill="both", expand=True, padx=20, pady=10)

    # Create the figure (re-using your logic)
    fig, ax = plt.subplots(figsize=(6, 4), dpi=100)
    ax.plot(yearly_avg["Year"], yearly_avg["Mean"], color="#e74c3c")
    ax.set_title("Temperature Trend (1850-2024)")
    ax.set_xlabel("Year")
    ax.set_ylabel("Mean Anomaly")
    ax.grid(True, linestyle='--', alpha=0.6)

    # Place chart in Tkinter
    canvas = FigureCanvasTkAgg(fig, master=chart_frame)
    canvas.draw()
    canvas.get_tk_widget().pack(fill="both", expand=True)

    # 5. Footer/Exit
    exit_btn = ttk.Button(root, text="Close Dashboard", command=root.destroy)
    exit_btn.pack(pady=10)

    root.mainloop()

# Run the GUI
launch_gui()
```



References

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Section 6: Conclusion, Version Control and Critical Appraisal

Conclusion

This project examined a real-world global temperature dataset using Python.

The analysis of the global temperature dataset demonstrated the use of control structures and functions. It also made use of modules and the **Pandas** library for handling and processing the dataset.

The project successfully presented the global temperature dataset through data visualisation. In addition, a simple graphical user interface (GUI) was developed for interacting with the global temperature data.

The results showed that global temperatures are increasing over time, providing evidence that climate change is real. After cleaning and combining the data, the results became easier to interpret and understand. Visualisations such as charts and images were used to clearly demonstrate trends in temperature change.

The computer program developed during the project was easy to use. Users did not need prior programming knowledge to interact with it. As a result, the global temperature results were presented in a clear and accessible manner.

Overall, the project successfully achieved the learning outcomes of the module. It demonstrates how Python programming can be applied to real-world data analysis and highlights the usefulness of Python for analysing and presenting large datasets. The project therefore meets the learning objectives of the module and provides a strong example of Python-based data analysis.

Version Control

GitHub was used to track all changes made throughout the development of this coursework. The GitHub repository was organised clearly, with the Jupyter Notebook serving as the central component of the project.

The key purposes of version control include:

- Tracking changes made to the code
- Managing different versions of the software
- Supporting collaborative work on a shared project

The main version control practices followed during this coursework were:

- Regular commits were made after completing each major section of the coursework
- Commit messages clearly described the changes that were made
- The GitHub repository helped track progress and ensured the work could be reproduced

Using GitHub was important because it allowed the development process to be reviewed and ensured that the coursework remained organised, transparent, and reliable.

Report

The whole project is written in a single Jupyter Notebook that focuses on analysing global temperature data and climate change trends. The notebook brings together explanations, code, results, and visualisations in an organised way, making the analysis easy to understand and reproduce. The report is divided into the following sections.

Introduction

Global temperature is really important when we talk about climate change. If we look at the hundred years the temperature on the surface of the earth has been going up and up. This is because of all the things people have been doing like sending a lot of greenhouse gases into the air building more factories and using land in ways that hurt the environment. When we know what is happening with the temperature over a time it helps people who study the earth people who make decisions for our country and people who do research figure out how fast the earth is getting warmer and what bad things might happen to the earth to peoples money and, to our lives.

Methodology

The methodology section explains how the global temperature data is processed and analysed. This includes cleaning the dataset, dealing with missing values, preparing the data for analysis, and applying appropriate analysis methods. Time-based analysis methods are used to examine how global temperatures change over time, and visualisation techniques are used to show long-term trends and seasonal variations.

The global temperature data is carefully analysed to identify important patterns and changes. Each step of the analysis is explained clearly, making it easy to understand how the data is handled and why each step is performed.

Findings

The findings section remember the main insights gained from analysing the global temperature data. Visualisations such as line graphs and charts are used to show long-term increases in global temperatures and to highlight significant temperature changes that stand out.

The results are explained in simple and clear terms. The discussion focuses on how the observed temperature trends relate to climate change and global warming. The global temperature analysis provides the basis for understanding how temperatures have changed over time and how these changes connect to climate change.

Code Documentation

Code documentation is employed in the Jupyter Notebook to ensure the global temperature and climate change analysis explained in this piece becomes clear to follow. Code documentation makes it easier to understand due to clear explanations of important steps such as loading data, cleaning data, and visualization.

Inline comments refer to adding explanations of the function of selected lines or pieces of code, particularly when dealing with the global temperatures, missing values, as well as the creation of graphs. These comments refer to explanations that clarify the function of the selected part of the code to the reader without necessarily studying the code closely.

Docstrings are added wherever function usage occurs. This explains what function it is, what arguments it accepts, as well as what it returns. This allows the code to be reusable.

Thus, use of comments and docstrings is important because it helps make the analysis-readable and reproducible by other individuals. Furthermore, this is evidence of sound coding and documentation practice

Skills

This coursework demonstrates key skills developed during the module. GitHub is used effectively for version control, showing the ability to manage and track changes in a data analysis project. Technical writing skills are demonstrated through clear and structured explanations of the global temperature and climate change analysis. In addition, strong coding and documentation skills are shown through the consistent use of comments and docstrings throughout the notebook.

Critical Appraisal

The project was critically evaluated to assess the quality of the code, its performance, and the limitations of the analysis. This evaluation helped identify both strengths and areas for improvement.

Strengths

- The use of modular functions made the code easier to read and reuse
- Modular programming improved both code readability and reusability
- The **Pandas** library was effective in supporting data manipulation and aggregation
- The visualisations clearly communicated trends and insights within the data
- The GUI enhanced usability for non-technical users

Limitations

- The dataset represents global averages and does not capture regional temperature variations in detail
- The graphical user interface is relatively simple and could be further developed
- The analysis is descriptive and does not include predictive modelling

Future Improvements

- Add region-wise or country-wise temperature analysis

- Include more interactive visualisations using advanced libraries
- Implement predictive models to forecast future temperature trends

In [ ]:
```

```