Global Air Temperatures and Precipitation Patterns Analysis

1. Introduction

The goal of this report is to examine trends in global air temperature for the period of 1922-2021 and explore changes in the global rate of precipitation for the years 1951-2021. Furthermore, it also elaborates on how both climate variables are related to one another.

Main Questions

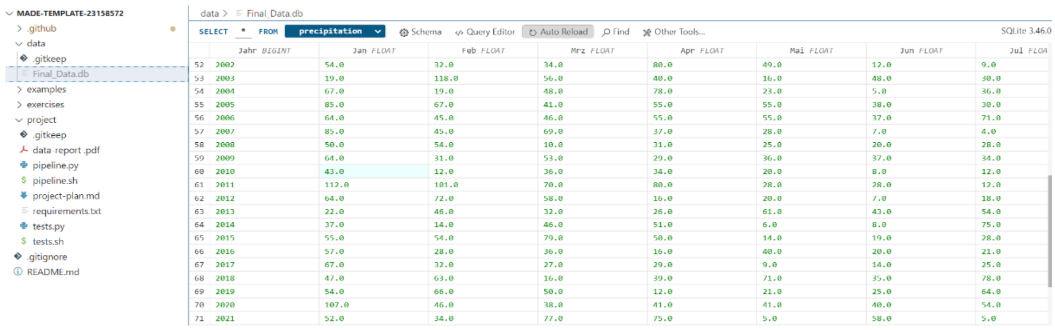
- How have global air temperatures changed from 1922 to 2021?
- What are the observed changes in global precipitation patterns from 1951 to 2021, and how do these changes correlate with the trends in global air temperatures?

2. Used Data

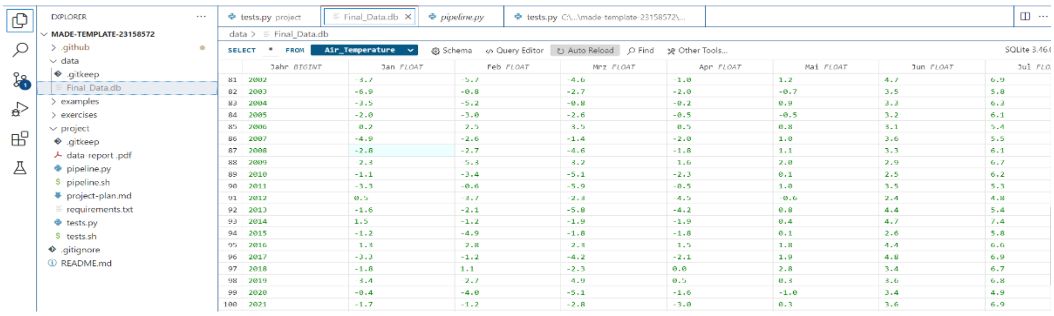
The analysis is based on two primary datasets: weather data such as precipitation and temperature. The precipitation dataset has 71 **entries** while the temperature dataset has 100 **entries**. Each dataset is structured with a single column representing monthly data over several years. Namely, the names of the columns are the year and the months from January to December separated by a semicolon. This format indicates a **time-series structure** with monthly observations over multiple years.The precipitation data in millimeters quantifies the monthly rainfall from the year 1951 to the year 2021. The temperature data includes monthly average temperatures in degree Celsius for the years between 1922 and 2021. The structure of these datasets allows for a comprehensive analysis of historical weather patterns.

The license of the two datasets is the **CC BY 4.0** license. These datasets are freely available for distribution, use, and adaptation, provided proper attribution is given to the original creators.

Result: Output of the pipeline



	Jahr BIGINT	Jan FLOAT	Feb FLOAT	Mrz FLOAT	Apr FLOAT	Mai FLOAT	Jun FLOAT	Jul FLOA
52	2002	54.0	32.0	34.0	80.0	49.0	12.0	9.0
53	2003	19.0	118.0	56.0	40.0	16.0	48.0	30.0
54	2004	67.0	19.0	48.0	78.0	23.0	5.0	36.0
55	2005	85.0	67.0	41.0	55.0	55.0	38.0	30.0
56	2006	64.0	45.0	46.0	55.0	55.0	37.0	71.0
57	2007	85.0	45.0	69.0	37.0	28.0	7.0	4.0
58	2008	50.0	54.0	10.0	31.0	25.0	20.0	28.0
59	2009	64.0	31.0	53.0	29.0	36.0	37.0	34.0
60	2010	43.0	12.0	36.0	34.0	20.0	8.0	12.0
61	2011	112.0	101.0	70.0	80.0	28.0	28.0	12.0
62	2012	64.0	72.0	58.0	16.0	20.0	7.0	18.0
63	2013	22.0	46.0	32.0	26.0	61.0	43.0	54.0
64	2014	37.0	14.0	46.0	51.0	6.0	8.0	75.0
65	2015	55.0	54.0	79.0	50.0	14.0	19.0	28.0
66	2016	57.0	28.0	36.0	16.0	40.0	20.0	21.0
67	2017	67.0	32.0	27.0	29.0	9.0	14.0	25.0
68	2018	47.0	63.0	16.0	39.0	71.0	35.0	78.0
69	2019	54.0	66.0	50.0	12.0	21.0	25.0	64.0
70	2020	107.0	46.0	38.0	41.0	41.0	40.0	54.0
71	2021	52.0	34.0	77.0	75.0	5.0	58.0	5.0



	Jahr BIGINT	Jan FLOAT	Feb FLOAT	Mrz FLOAT	Apr FLOAT	Mai FLOAT	Jun FLOAT	Jul FLO
81	2002	-3.7	-5.7	-4.6	-1.0	1.2	4.7	6.9
82	2003	-6.9	-0.8	-2.7	-2.0	-0.7	3.5	5.8
83	2004	-3.5	-5.2	-0.8	-0.2	0.9	3.3	6.3
84	2005	-2.0	-3.0	-2.6	-0.5	-0.5	3.2	6.1
85	2006	0.2	2.5	3.5	0.5	0.8	3.1	5.4
86	2007	-4.9	-2.6	-1.4	-2.0	1.0	3.6	5.5
87	2008	-2.8	-2.7	-4.6	-1.8	1.1	3.3	6.1
88	2009	-2.3	-5.3	-3.2	-1.6	2.0	2.9	6.7
89	2010	-1.1	-3.4	-5.1	-2.3	0.1	2.5	6.2
90	2011	-3.3	-0.6	-5.9	-0.5	1.0	3.5	5.3
91	2012	0.5	-3.7	-2.3	-4.5	-0.6	2.4	4.8
92	2013	-1.6	-2.1	-5.8	-4.2	0.8	4.4	5.4
93	2014	1.5	-1.2	-1.9	-1.9	0.4	4.7	7.4
94	2015	-1.2	-4.9	-1.8	-1.8	0.1	2.6	5.8
95	2016	1.3	2.8	2.3	1.5	1.8	4.4	6.6
96	2017	-3.3	-1.2	-4.2	-2.1	1.9	4.8	6.9
97	2018	-1.8	1.1	-2.3	0.0	2.8	3.4	6.7
98	2019	-3.4	-2.7	-4.9	0.5	0.3	3.6	6.8
99	2020	-0.4	-4.0	-5.1	-1.6	-1.0	3.4	4.9
100	2021	-1.7	-1.2	-2.8	-3.0	0.3	3.6	6.9

3. Analysis

3.1 How have global air temperatures changed from 1922 to 2021?

The Analysis has been done in this study utilizing Jupyter Notebook which is a powerful and flexible open-source web application. With this tool, one could write code, execute it and include visualisations all in one document which made the analysis and reporting process easy. Here, Figure 1 portrays a warming trend in the global air temperature from the year 1922 to 2021 with the steepest rise in the recent years. The horizontal red dashed line in Figure 1 at zero point is the base average temperature. Temperatures above this line are warmer than the average while those below the line depict cooler temperatures. The trend is slightly declining around 1950s and 1960s and there are years with negative anomalies. Since the late 1970s, there is a clear upward trend in the temperature anomalies above the baseline and the trend has been on the rise. The latest years of the presented data set reveal the highest positive deviations, which means that the increase is considerable of global temperature.

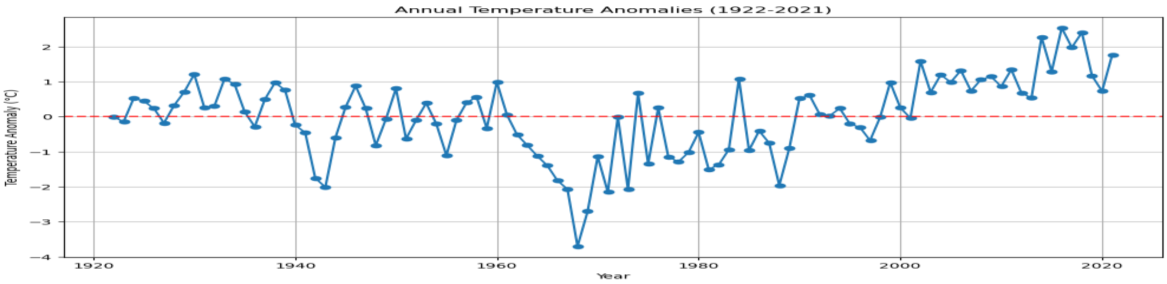


Figure 1:Yearly Global Air Temperature Fluctuation

In Figure 2, there is a bar graph with the title “Average Monthly Temperatures (1922-2021)” where each bar corresponds to the average temperature of the particular month from all the years of the dataset. When it comes to the months of December, January and February, the temperatures are negative which implies cold weather that is associated with winter season. There is a gradual rise in the temperatures; April and May record temperatures of around or slightly above zero which illustrates the rising temperatures of spring. The maximum temperatures are observed in July and August and average the values of 5-6°C, which indicates the warmest period of the year.

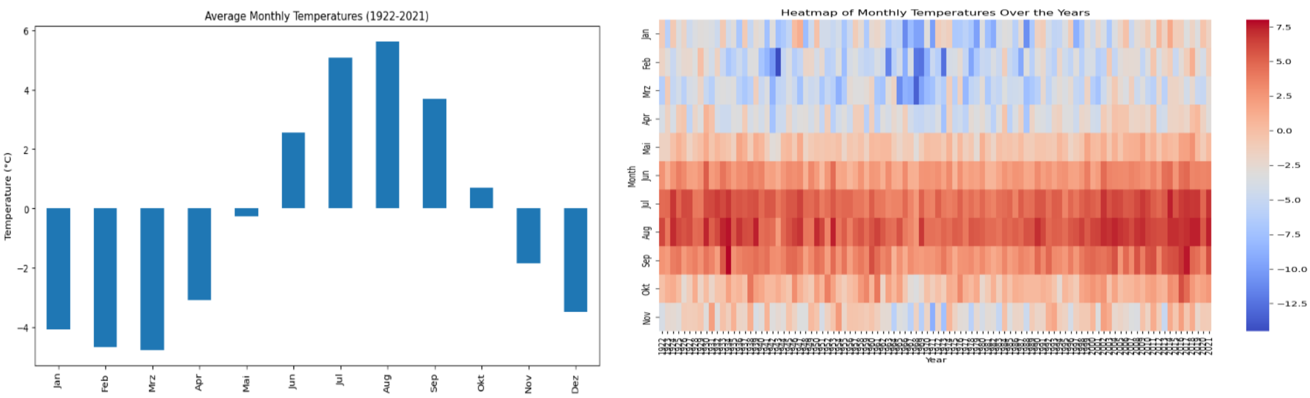


Figure 2: Monthly Temperature

The temperatures start to decline again, with September still being relatively warm, and a significant drop in November. Additionally, the heatmap shows there is a clear long-term warming trend, with recent years showing consistently higher temperatures, especially during summer months. Winter months show cooler temperatures and summer months show warmer temperatures.The Figure 3 is the forecast line shows a steady increase in temperature from 1920 to 2030. A line graph with a dashed line representing the forecast and a solid line representing actual temperatures. The actual temperature line matches the forecast line up to

2000 but then starts to increase more rapidly than the forecast. By 2030, the actual temperature is forecast to be about 2 degrees Celsius higher than what was forecast in 1922.

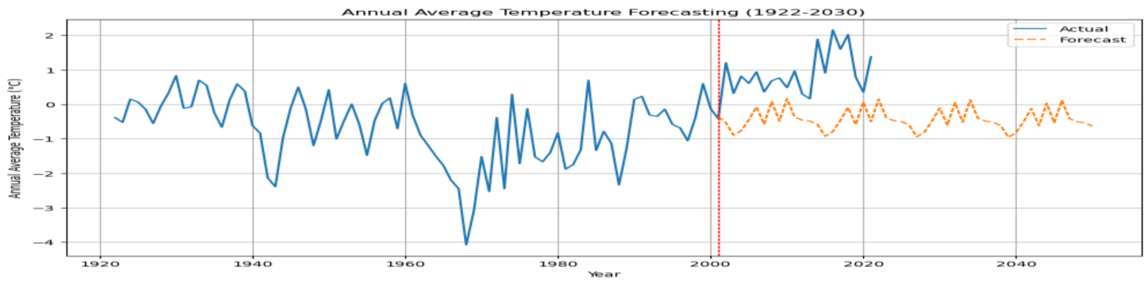


Figure 3: Temperature Forcasting

3.2 .1 What are the observed changes in global precipitation patterns from 1951 to 2021?

The plots of two visualizations from Figure 4 demonstrate the variability and long-term trends of precipitation annually and seasonally. Annually, the pattern shows significant fluctuations in precipitation. There are several peaks and troughs, indicating years with high and low precipitation. In the case of season, summer precipitation tends to be lower than other seasons. There is significant variability, and some years show very low summer precipitation. In winter, precipitation shows some of the highest peaks, indicating years with substantial winter precipitation. However, it also shows considerable variability with some years having very low precipitation. Fall has some high peaks, indicating substantial precipitation in certain years. Similar to Spring and Winter, Fall precipitation shows considerable variability.

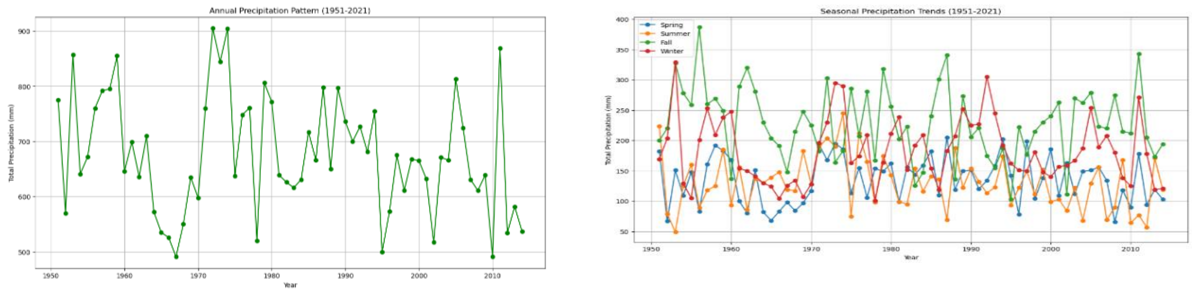


Figure 4: Precipitation variability

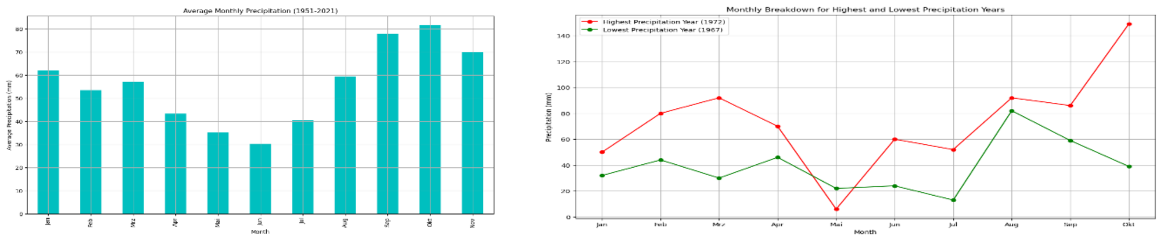


Figure 5: Peak and Low Precipitation Trends

This bar chart in Figure 5 shows the average of monthly precipitation from January to November for the years 1951 to 2021. From the data collected, it is found that the month of October (Okt) and November (Nov) have the highest average rainfall. However, the precipitation in the month of May (Mai) and June (Jun) is comparatively low compared to the other months. Next, the line graph of the same figure shows the comparison and brings out the fluctuation in the monthly precipitation between the two years. It is possible to highlight significant differences in precipitating conditions between these two years, especially during the warm period and in the late summer-fall. The year with the highest amount of precipitation is 1972 with marked high amounts of precipitation in March and October. The year with the least amount of precipitation (1967) shows a more uniform but comparatively less amount of precipitation during a year.

3.2.2 how do these changes correlate with the trends in global air temperatures?

Correlation Coefficients are used to demonstrate the correlation between global air temperatures and precipitation. The values range from -1 to 1(Correlation Coefficients).If the coefficients are positive, then there is a direct relationship between the variables; if it is negative, then there is an inverse relationship between the variables. Some of the seasonal patterns have some months' temperature equivalent to specific months' precipitation. For example, the late summer months of August have substantial positive coefficients with the autumn months of October and November precipitation. The Highest positive correlation of warmer January temperatures with March and September precipitation. Next, Notable positive correlation with August precipitation (0.37), indicating a potential link between warmer February temperatures and increased August precipitation. After that, the Strongest positive correlation of August in the matrix with October precipitation (0.48). Some negative correlation also happens in the same way. Such as, August has a Negative correlation with April (-0.24) and May (-0.22) precipitation and a Negative correlation of May with August (-0.21) and February (-0.17) precipitation.

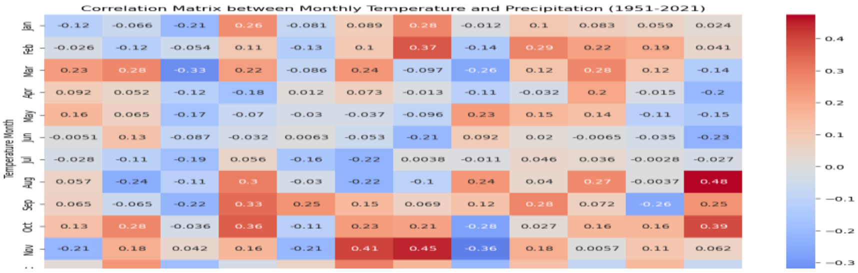


Figure 6: Correlation Coefficients Values

4. Conclusions

This data Analysis project has revealed real-world insights regarding air temperature and precipitation. According to the above analysis, the global air temperature is increasing rapidly. This trend contributes to climate change in a bad way. Annually, precipitation exhibits significant fluctuations with pronounced peaks and troughs, indicating years with varying levels of precipitation The precipitation has both a negative and positive correlation with air temperature. Positive correlation coefficients suggest a direct relationship where warmer temperatures in certain months are associated with increased precipitation in specific subsequent months, while negative coefficients indicate an inverse relationship where warmer temperatures in certain months are linked with reduced precipitation in following months. These findings therefore support the idea that the correlation between air temperatures and precipitation is not linear and can be influenced by a number of factors with implications for understanding climate behavior.

Limitation: the correlation between air temperature and precipitation has notable **limitations.** The correlations do not account for allinfluencing factors, such as atmospheric pressure, wind patterns, and geographic variations, which can also significantly impact precipitation