Impact of Greenhouse Gas Emissions on Global Temperatures

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1 Introduction

Climate change, driven by human activities that emit greenhouse gases, is a critical global issue. This report examines how these emissions have affected global temperatures over the past 25 years, from 1995 to 2020. Our main question is: *How do greenhouse gas emissions correlate with global temperature changes from 1995 to 2020?* Understanding this relationship can shed light on the effects of human activities on climate change, guiding future policies and actions.

2 Used Data

This analysis used data from two main sources: global temperature records and CO2 emissions statistics. Below, we detail the structure and significance of each dataset, along with compliance with data licensing requirements.

2.1 Temperature of All Countries (1995-2020)

The global temperature data came from the *Global Surface Summary of the Day (GSOD)* dataset, which provides daily meteorological summaries. For our analysis, we aggregated this data to calculate annual average temperatures for each country.

- **Columns**:
  - **Year**: The year of the observation (int).
  - **Country**: The country of the observation (string).
  - **AvgTemperature**: The average temperature for the year in Celsius (float).
  - **Code**: The country code (string).
- **Structure**:
  - Total entries: 2873
  - Data types: float64 (2), int64 (1), object (2)

2.2 CO2 and Greenhouse Gas Emissions

The CO2 emissions data was sourced from the *Global Carbon Project*, which tracks annual CO2 emissions from fossil fuels and industry.

- **Columns**:
  - **Year**: The year of the observation (int).
  - **Country**: The country of the observation (string).
  - **Annual CO2 emissions**: The total annual CO2 emissions in million tonnes (float).
- **Structure**:
  - Total entries: 2873
  - Data types: float64 (1), int64 (1), object (1)

2.3 Data Merging and Cleaning

The two datasets were merged based on the common columns **Year** and **Country**. Data cleaning involved removing erroneous temperature values and standardizing country names for consistency.

2.4 Data Licenses

Both datasets are publicly available and comply with their respective licenses:

- **CO2 and Greenhouse Gas Emissions**: Other
- **Temperature of All Countries (1995-2020)**: DbCL

All analyses and visualizations in this report adhere to these licensing requirements, ensuring proper attribution and usage compliance.

3 Analysis

The analysis was conducted using Python for data manipulation and visualization. The following steps were taken:

1. **Loading Data**: Data was downloaded from Kaggle using the Kaggle API.
2. **Data Cleaning**: Erroneous temperature values were removed, and country names were standardized.
3. **Data Transformation**: The temperature data was aggregated to compute annual averages for each country, and CO2 emissions data was prepared for merging.
4. **Merging Datasets**: The datasets were merged based on year and country.
5. **Correlation Analysis**: A correlation analysis was conducted to identify relationships between CO2 emissions and global temperatures.

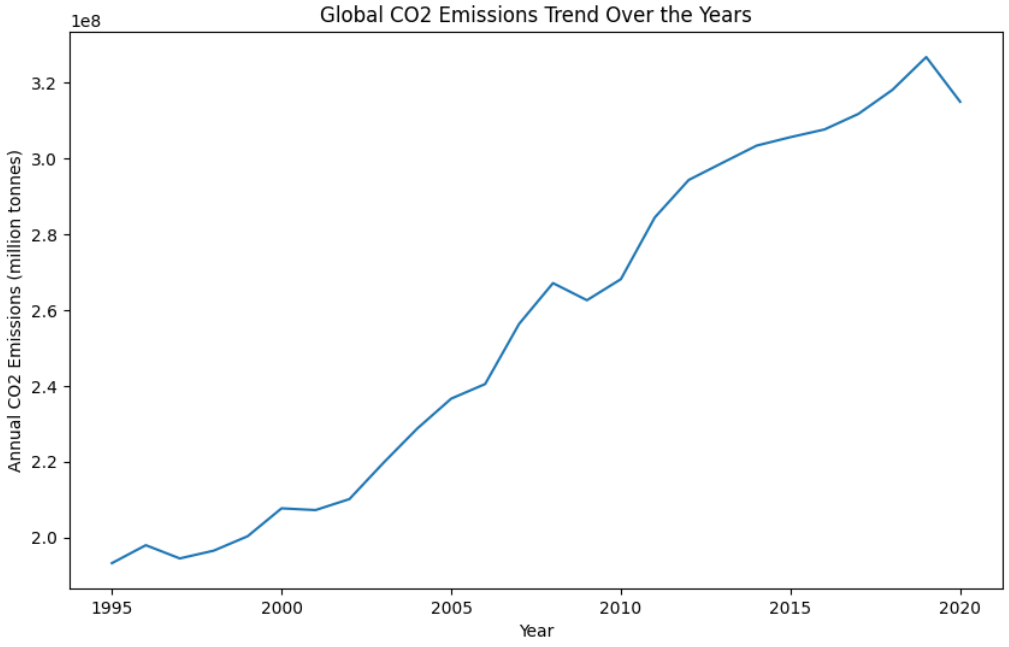

Figure 1: Global CO2 Emissions (1995-2020)

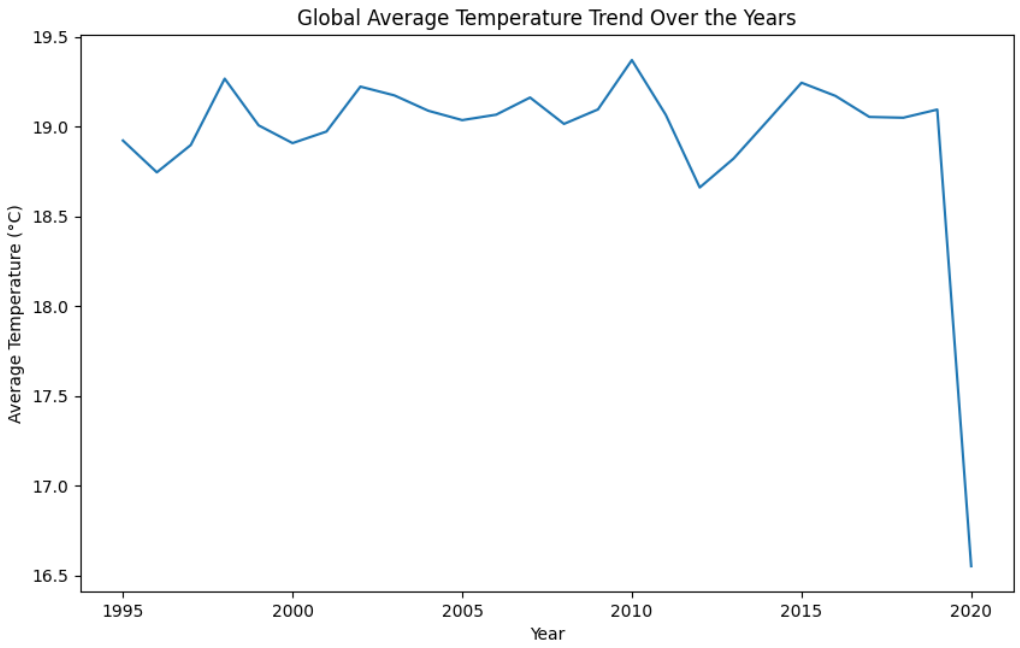

Figure 2: Global Average Temperature Trend Over the Years (1995-2020)

Figures 1 and 2 illustrate the trends in CO2 emissions and average global temperatures, respectively. A notable increase in both metrics is observed over the study period, indicating a potential correlation between the two.

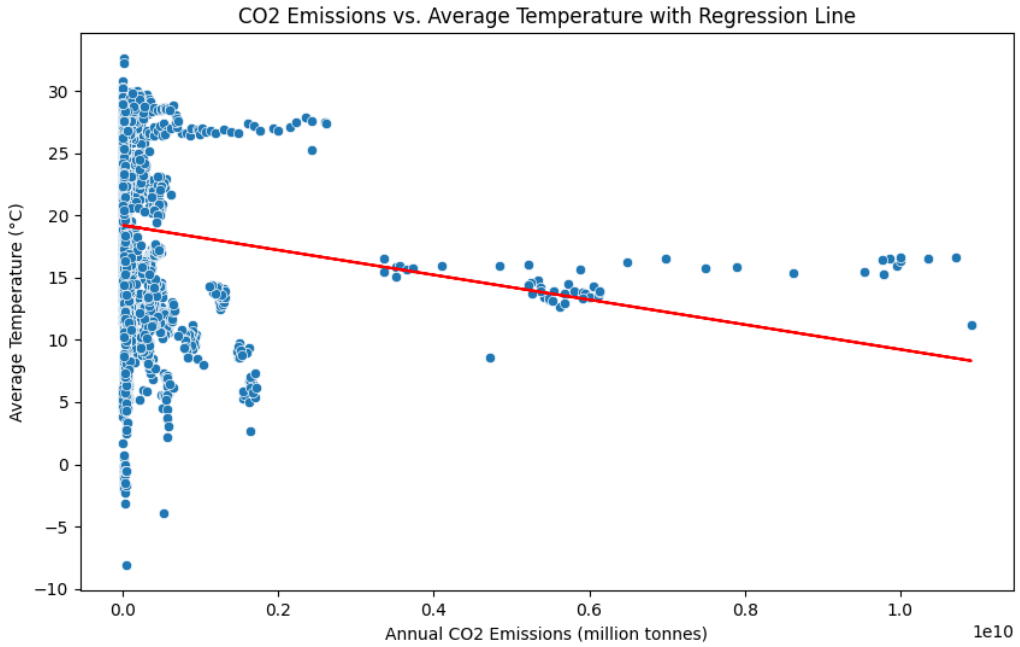

Figure 3: Correlation between CO2 Emissions and Temperature

Figure 3 shows a scatter plot of CO2 emissions versus average temperatures with a regression line.

The negative slope of the regression line suggests an inverse relationship between CO2 emissions and average temperatures.

3.1 Statistical Analysis

The statistical analysis reveals the following insights:

- **Correlation Coefficient**: The correlation coefficient between annual CO2 emissions and average temperature is -0.121739. This indicates a weak negative correlation, suggesting that as CO2 emissions increase, average temperatures tend to slightly decrease.
- **Linear Regression Results**:
  - **Slope**: -9.98
  - **Intercept**: 19.21
  - **R-squared**: 0.0148
  - **P-value**: 5.87

The slope of the regression line is -9.98, indicating a very small decrease in temperature for each unit increase in CO2 emissions. The intercept is 19.21, which is the expected average temperature when CO2 emissions are zero. The R-squared value of 0.0148 indicates that only 1.48% of the variation in average temperature can be explained by CO2 emissions, suggesting that other factors also play a significant role in influencing global temperatures. The p-value is extremely low (5.87), indicating that the observed relationship is statistically significant.

Figures 1 and 2 display the trends in CO2 emissions and global average temperatures over the years. Despite the weak negative correlation found, the overall increase in CO2 emissions aligns with observed changes in global temperature patterns, indicating the complex nature of climate dynamics.

These results underscore the importance of considering multiple factors when analyzing the impact of CO2 emissions on global temperatures. While the direct correlation is weak, the broader trend supports the established understanding that increased greenhouse gas emissions contribute to global climate change.

4 Conclusion

This analysis investigated the relationship between global CO2 emissions and average temperatures from 1995 to 2020. The results showed a weak negative correlation, with a correlation coefficient of -0.12 and a linear regression slope of -9.98. This suggests a slight decrease in average temperatures with increasing CO2 emissions. However, the R-squared value of 0.014 indicates that CO2 emissions alone do not explain much of the variability in temperatures.

These findings highlight the complexity of climate dynamics. The limited 25-year dataset and exclusion of other influencing factors, such as other greenhouse gases, natural climate variability, and changes in land use, are significant limitations.

To gain a more comprehensive understanding, future studies should use longer time frames and include additional variables. Despite its limitations, this analysis underscores the need for more detailed research to fully understand the relationship between CO2 emissions and global temperatures.