

Global CO_2 Emissions in 1997

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1 Background

1.1 Carbon Emissions

Carbon emissions refer to the release of carbon, particularly carbon dioxide (CO_2), into the atmosphere. This process primarily occurs through the burning of fossil fuels such as coal, oil, and natural gas, as well as through deforestation and various industrial processes. CO_2 is a greenhouse gas, meaning it traps heat in the Earth's atmosphere and contributes to the greenhouse effect, which leads to global warming and climate change.

In our report we are trying to understand the trend of the atmospheric CO_2 by asking the following research question:

Is there a significant upward trend in atmospheric CO_2 levels over time?

1.1.1 Null Hypothesis

There is no significant upward trend in atmospheric CO_2 levels over time. $H_0 : \beta_1 \leq 0$ Where: β_1 is the trend coefficient over time in a linear regression model of the form $CO2_t = \beta_0 + \beta_1 \cdot t + \epsilon_t$. $CO2_t$ is the atmospheric CO_2 level at time t .

2 Measurement and Data

2.1 Measuring Atmospheric Carbon

In this study, we will use the Mauna Loa Atmospheric CO_2 Concentration time series dataset that is available in R. The time series of 468 observations of the monthly Atmospheric concentrations of CO_2 from 1959 to 1997 expressed in parts per million (ppm). This means that, for example, a value of 320 means there are 320 CO_2 molecules for every 1 million air particles (after the water vapor is removed from the sample). The data was reported in the preliminary 1997 SIO (Keeling and Whorf, 1997).

The data were collected at the Mouna Loa Observatory which located on the island of Hawaii at an elevation of 11,135 feet above sea level which makes his location is “well situated to measure air masses that are representative of very large areas” Global monitoring laboratory - carbon cycle greenhouse gases (n.d.).

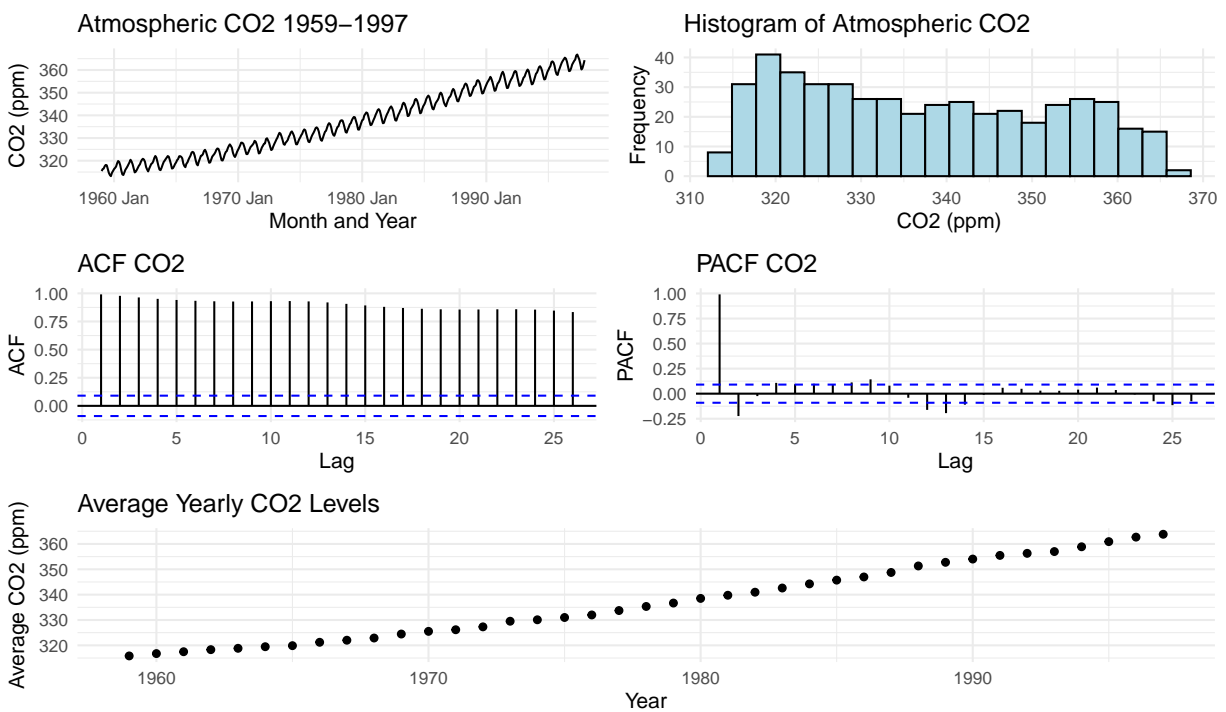
The values for February, March and April of 1964 were missing and have been obtained by interpolating linearly between the values for January and May of 1964.

2.2 Historical Trends in Atmospheric Carbon

The Keeling Curve is a graph of the accumulation of carbon dioxide in the Earth's atmosphere based on continuous measurements taken at the Mauna Loa Observatory on the island of Hawaii from 1958 to the present day. The curve is named for the scientist Charles David Keeling, who started the monitoring program and supervised it until his death in 2005 (Keeling Curve, 2024)

Atmospheric CO2 EDA plots

Upward trend with clear seasonal pattern



Source: Mauna Loa Atmospheric CO2 Concentration

Figure 1: Atmospheric CO2 EDA standard plots

As we see in Figure 1 the time series in the top left, there is a pretty strong seasonality as well as a linear upward trend. This dataset is not mean stationary but it may be variance stationary.

The ACF tails off very slowly while the PACF drops shortly after lag 1 but still have oscillating pattern. This suggests that this series may have a unit root.

The histogram in Figure 1 top right shows that there is a wide range of values with a slight right skew. The yearly average plot on the bottom illustrates the linear trend in the data series more explicitly.

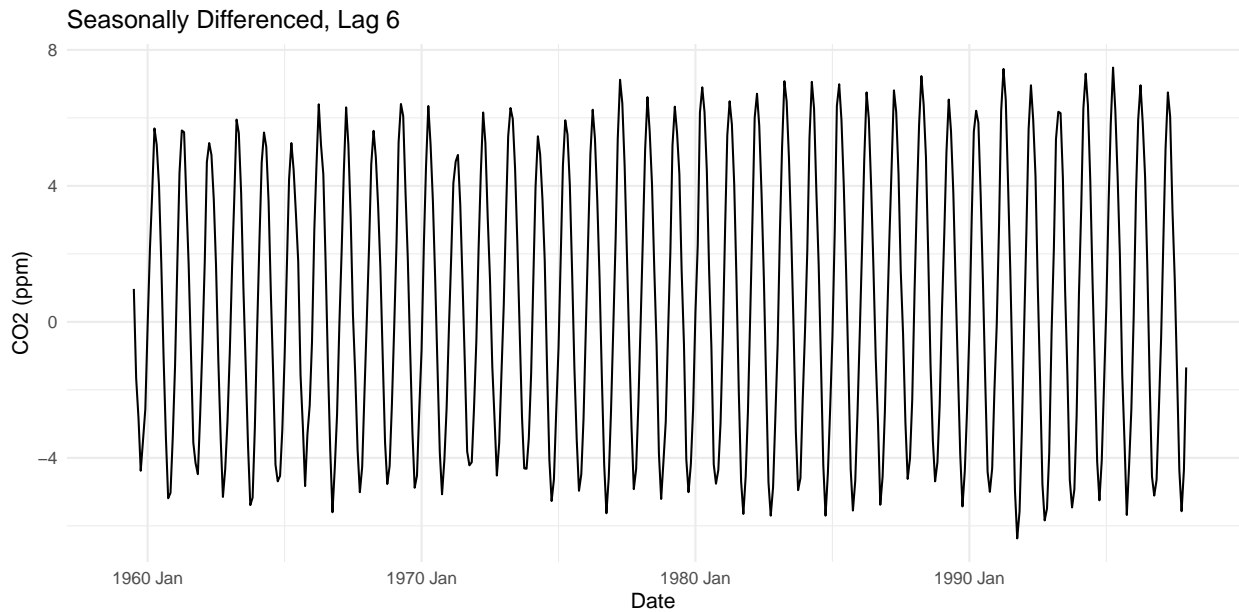


Figure 2: Seasonally Differenced CO2 Concentrations (Lag 6)

Based on the Figure 1 and after examining the time series more closely, we noted that the seasonal cycle seemed to be 6 lags long, we applied a seasonal differencing of 6 lags. This transformation resulted in a stationary series.

To confirm this we performed KPSS unit root test. With p-value of 0.1, fail to reject null hypothesis of stationarity, indicating that the transformed series is now stationary Figure 2

3 Models and Forecasts

3.1 Linear Models

3.2 ARIMA Models

3.3 Forecasts

4 Conclusions

5 References

ESRL global monitoring laboratory - mauna loa observatory n.d. Available at <https://gml.noaa.gov/obop/mlo/>

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Keeling, C D and **Whorf, T P** 1997 Scripps institution of oceanography (SIO), university of california, la jolla, california USA 92093-0220.

Keeling Curve 2024. *Wikipedia*. Available at https://en.wikipedia.org/w/index.php?title=Keeling_Curve&oldid=1223091306 [Last accessed 10 July 2024].