

Data driven analysis of Global Warming Causes



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Abstract

- We analyzed global temperature records alongside potential climate drivers to explore their relationships.
- Land temperatures (Berkeley Earth) and ocean temperatures (HadSST4) were merged into a global anomaly series with uncertainties. This was compared to atmospheric CO₂ (Mauna Loa), solar irradiance, and volcanic activity indices.
- Statistical tests show a strong correlation between CO₂ and global temperature anomalies, with weaker links for solar and volcanic factors, which appear tied to short-term variability. The results offer a data-based framework for assessing the roles of natural and human influences on climate change.

Motivation

- Climate change is a globally recognized issue with environmental, social, and economic impacts. Global average temperatures have risen by over 1 °C since the late 19th century, but the relative influence of human and natural factors remains under investigation.
- Greenhouse gases, particularly CO₂, trap heat in the atmosphere, while natural factors such as solar variability and volcanic eruptions can cause shorter-term fluctuations.
- This project uses long-term datasets from multiple trusted sources to examine temperature trends and compare them with CO₂ concentrations, solar irradiance, and volcanic activity. The goal is to build a clear, data-driven understanding of how these variables relate over time.

Data Sources

Global Land Temperature	Berkeley Earth
Global Sea Surface Temperature	HadSST4
Atmospheric CO ₂	NOAA GML Mauna Loa
Solar Irradiance	PMOD/WRC TSI
Volcanic Eruption Index	Smithsonian GVP VEI
Volcanic Aerosols	NASA GISS AOD
Climate Assessments	IPCC Reports

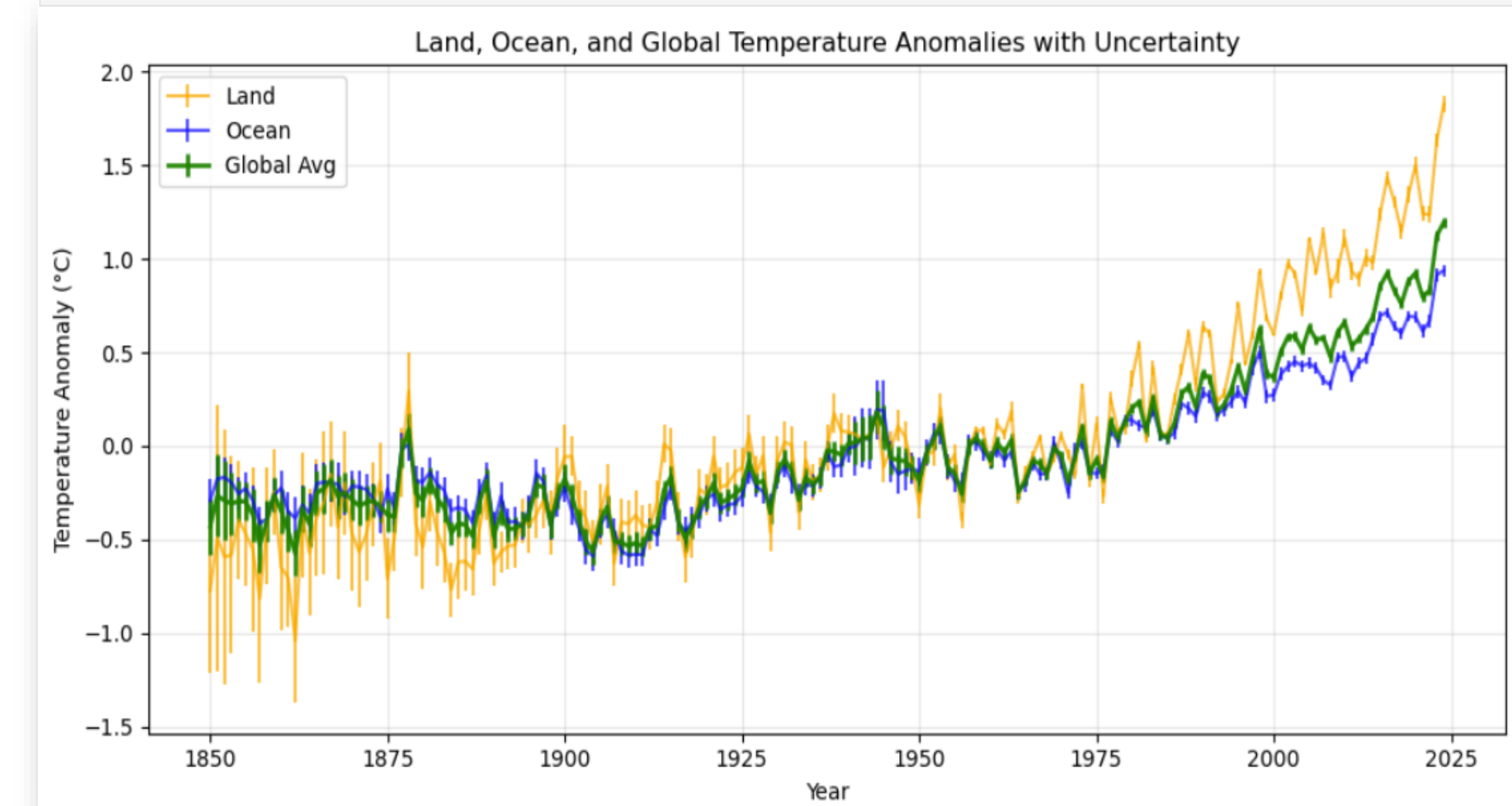
Data Processing & Curation

- Merged Berkeley Earth (land) and HadSST4 (ocean) temperature anomalies using area weighting (29% land, 71% ocean).
- Converted all datasets to annual resolution and aligned timelines; handled missing values.
- Propagated measurement uncertainties from each source into the combined global series to produce error bars.

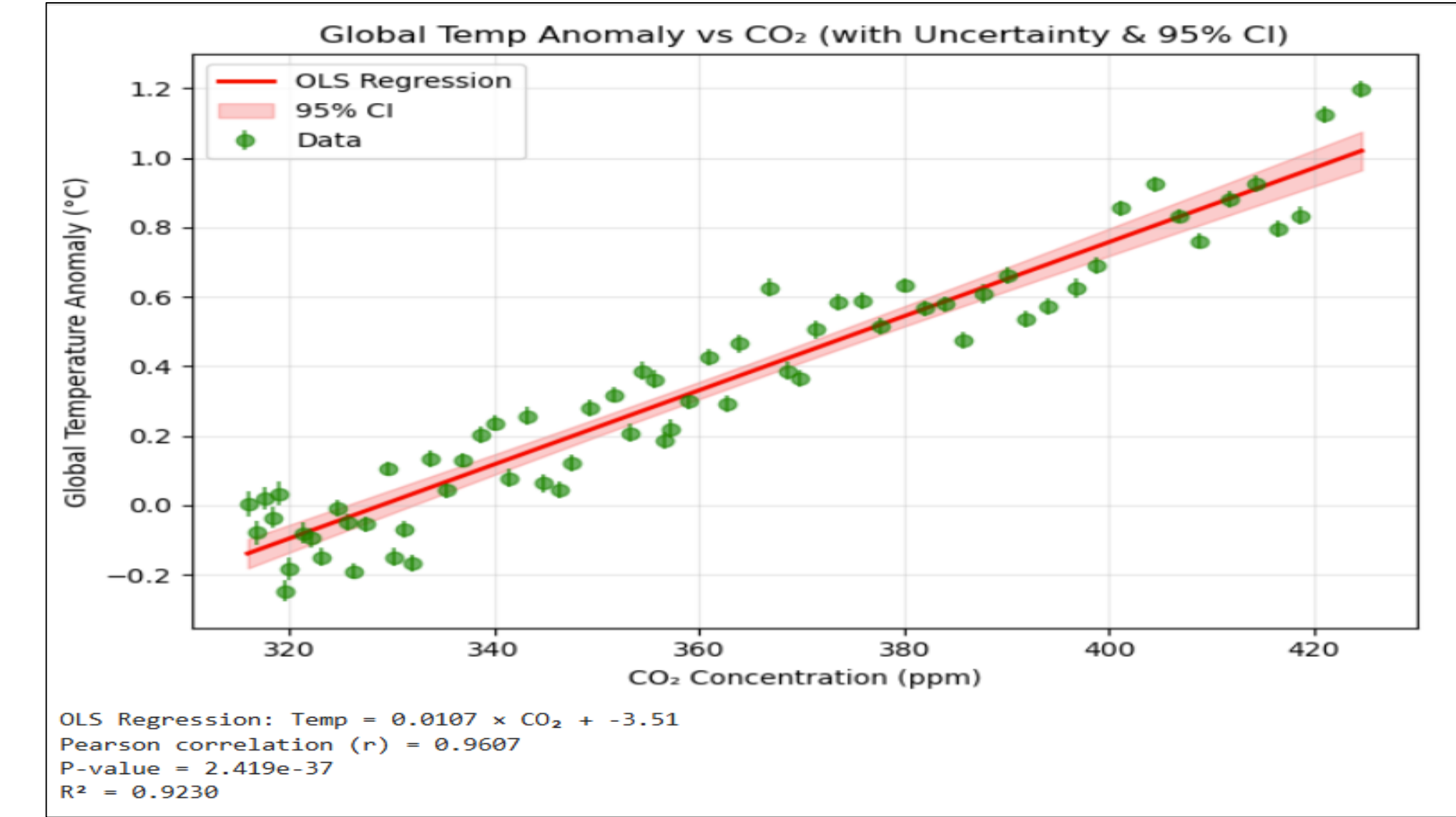
Methodology

Statistical Analysis

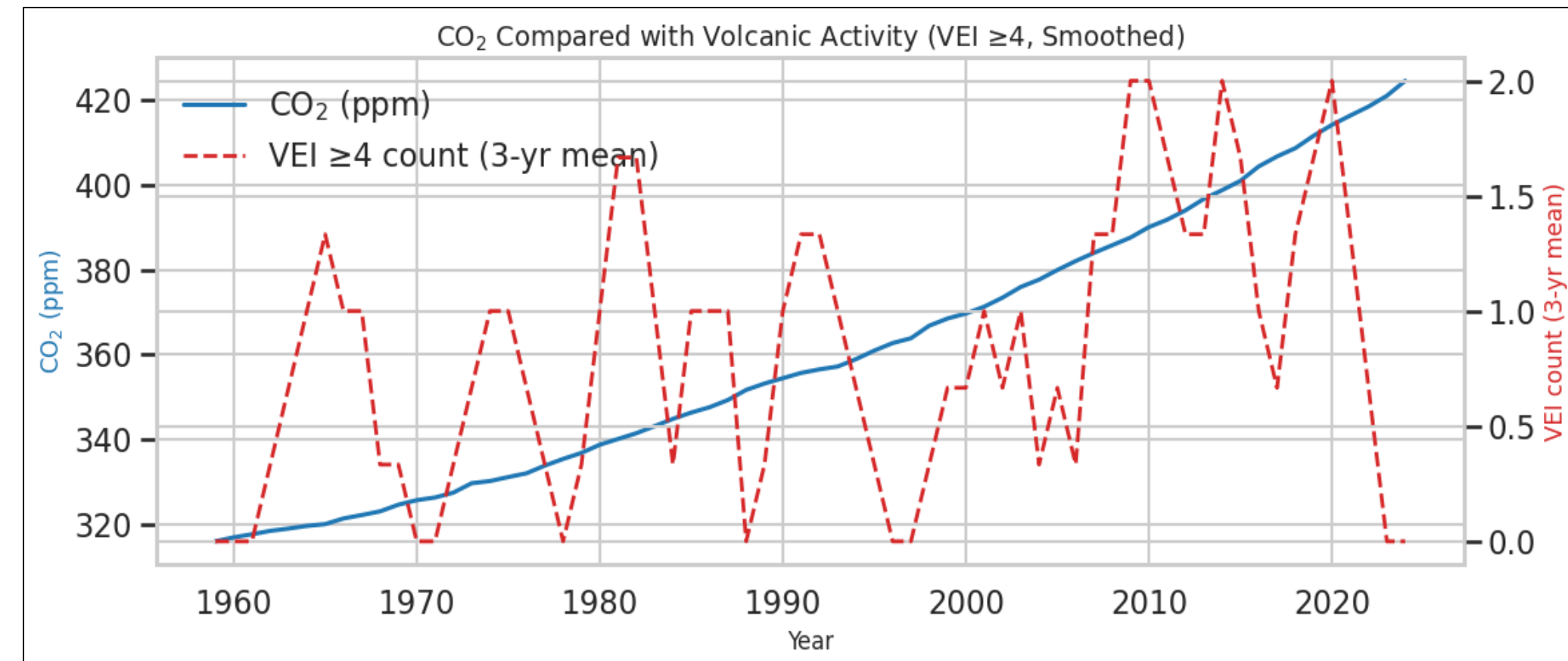
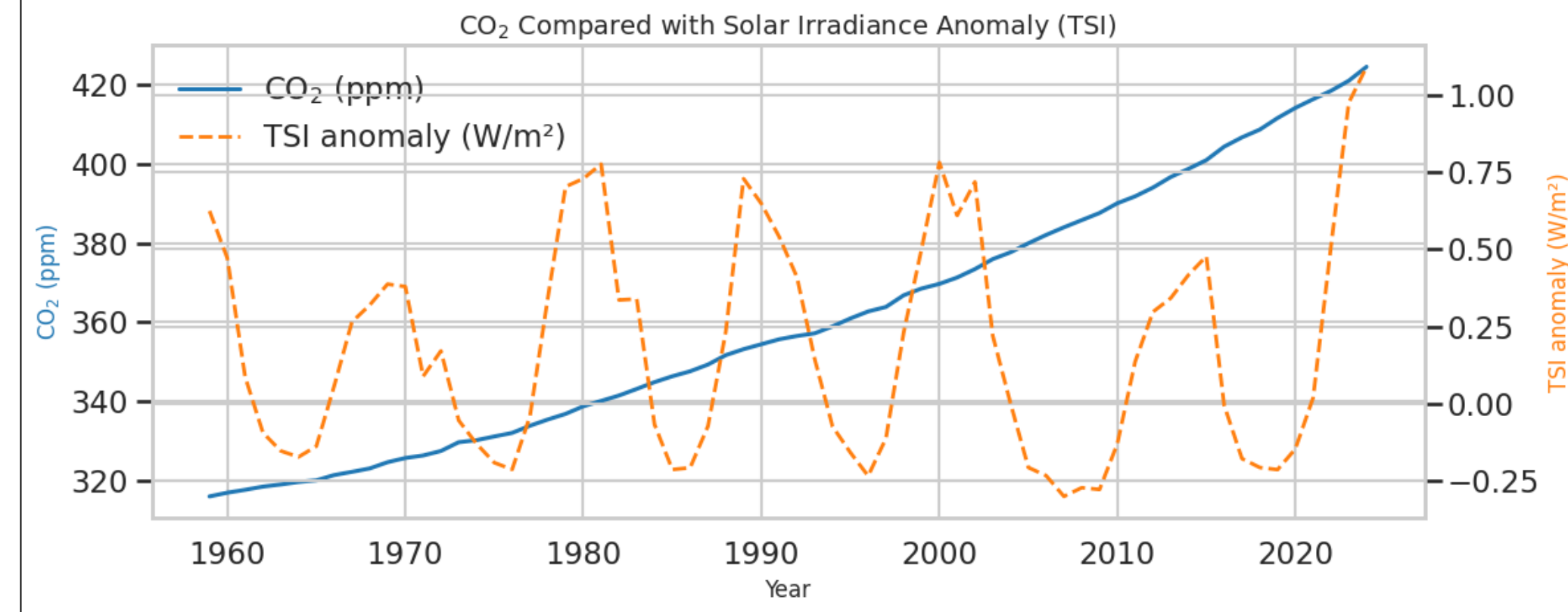
- Calculated trends in global temperature anomalies.



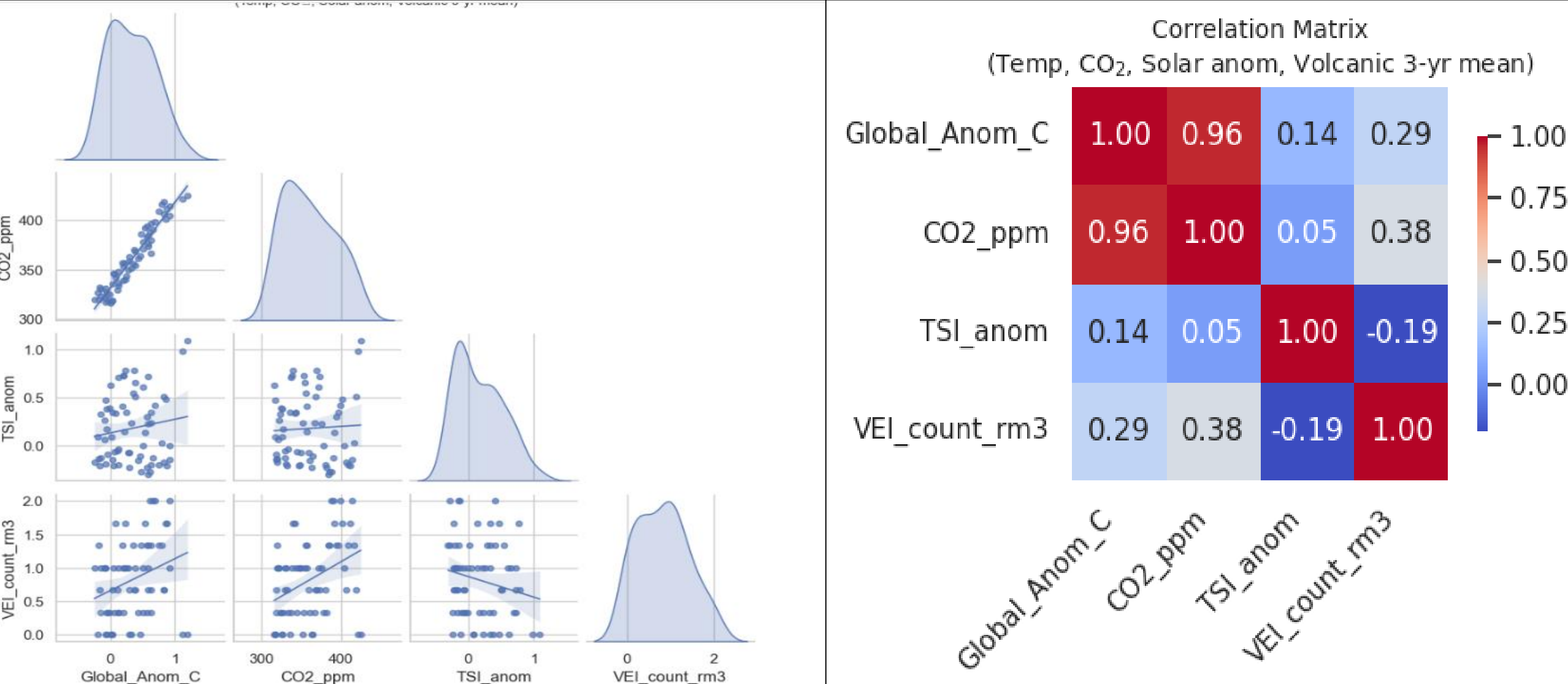
- CO₂ vs Global Temperature Correlation



- CO₂ Comparison with Solar and Volcanic Activity



Correlation and Scatterplot



The scatterplot shows a strong positive correlation between atmospheric CO₂ levels and global temperature anomalies

Regression Analysis

Model 1: Temp ~ CO₂

Variable	Coef	95% CI	p-value
Intercept	-3.5119	[-3.839, -3.185]	<0.001
CO ₂ (ppm)	0.0107	[0.010, 0.012]	<0.001

R² = 0.923
Adj. R² = 0.922
F-stat = 531.2
p = 1.1e-32

Model 2: Temp ~ CO₂ + TSI + VEI

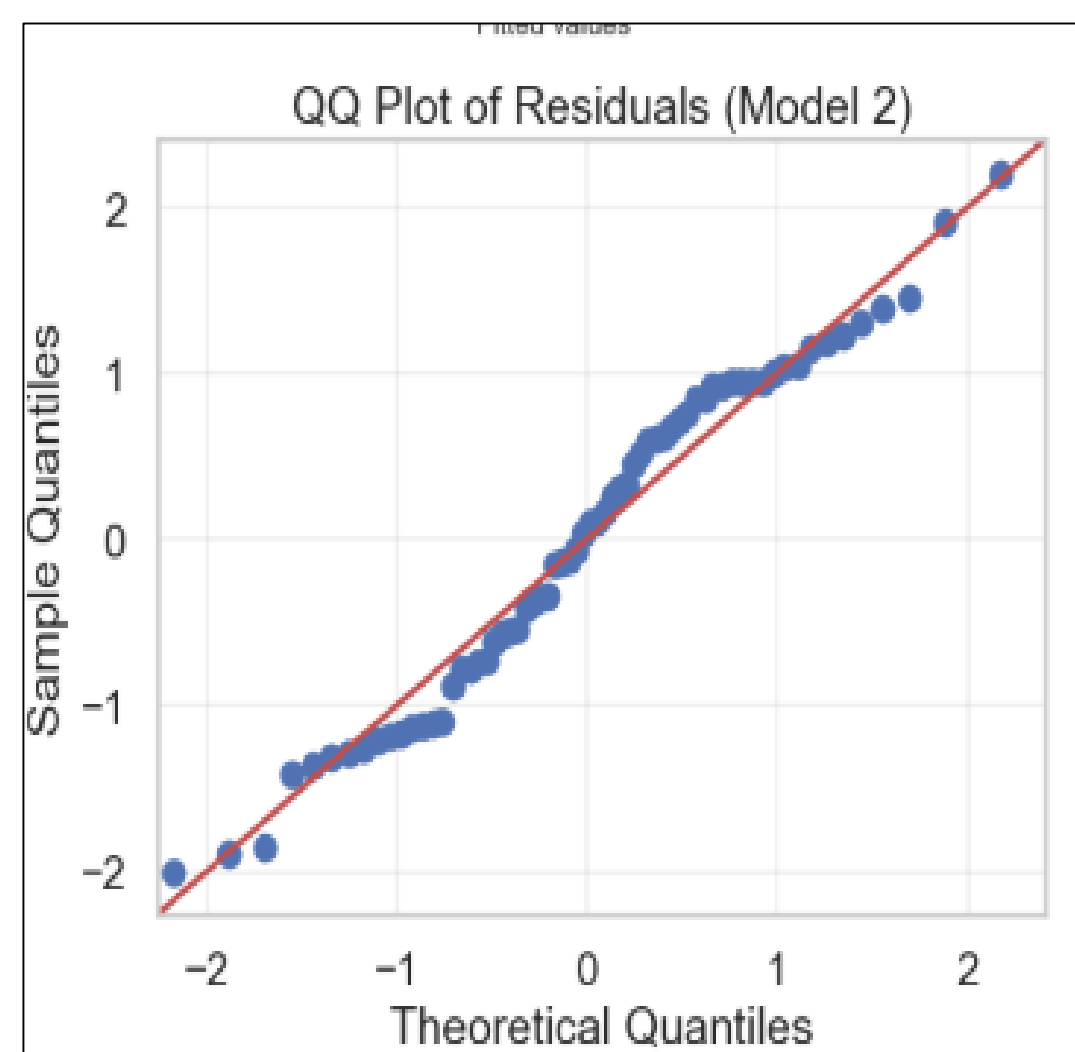
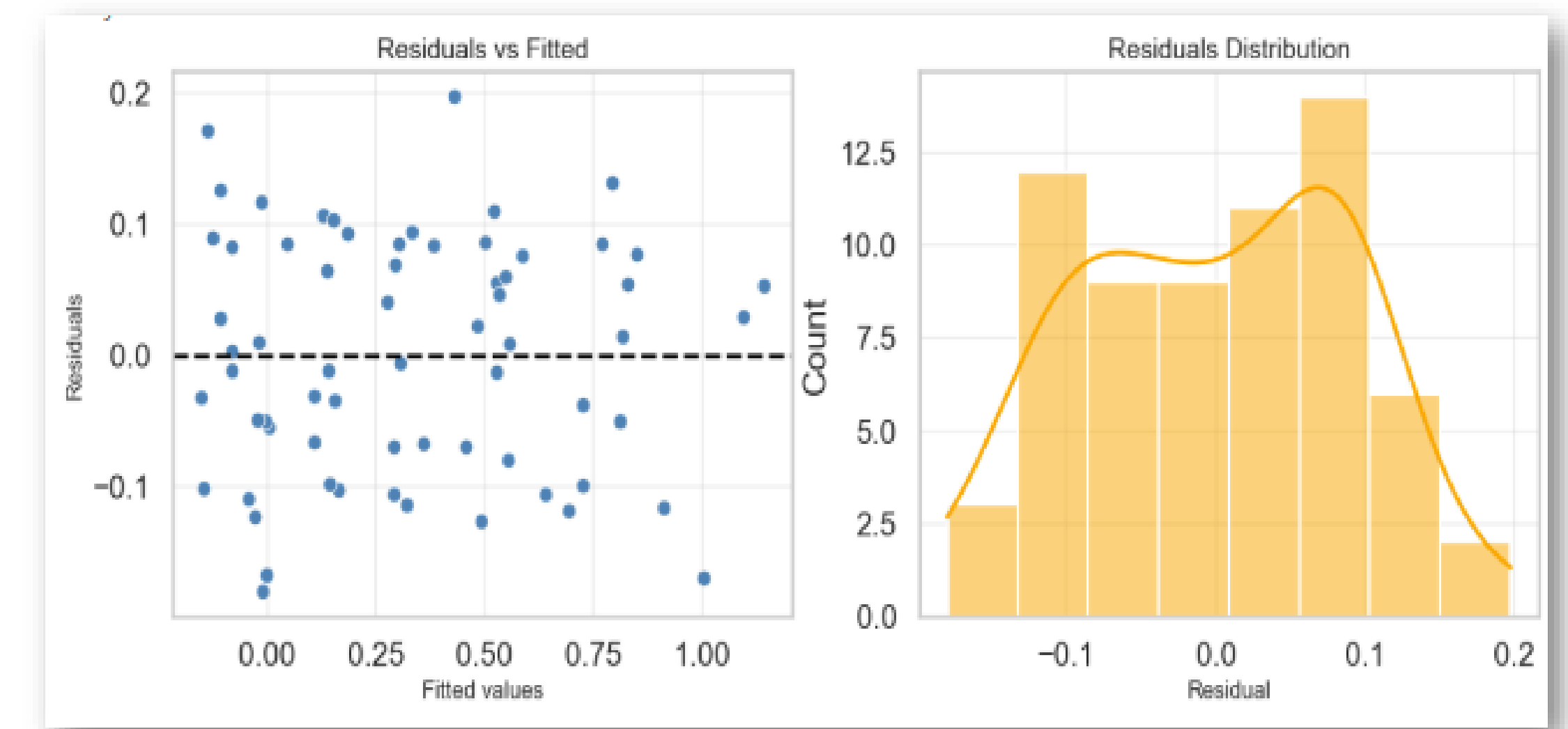
Variable	Coef	95% CI	p-value
Intercept	-3.5768	[-3.844, -3.310]	<0.001
CO ₂ (ppm)	0.0109	[0.010, 0.012]	<0.001
TSI anomaly	0.0824	[0.027, 0.138]	0.004
Volcanic VEI (3yr mean)	-0.0397	[-0.076, -0.003]	0.033

R² = 0.936
Adj. R² = 0.933
F-stat = 275.2
p = 9.1e-36

- The regression analysis shows a very strong positive relationship between atmospheric CO₂ levels and global temperature anomalies (R² = 0.923), which remains robust when accounting for solar irradiance and volcanic activity (R² = 0.936).
- Natural factors have smaller, short-term effects, while CO₂ is the dominant driver of the observed long-term warming trend.

ANOVA model comparison & partial F-test

ANOVA was used to compare a simple regression model (temperature ~ CO₂) with an extended model that included solar irradiance and volcanic activity, to test whether the additional predictors improved explanatory power.



Model 1: Temp ~ CO ₂
R ² : 0.923
Adj R ² : 0.922
Model 2: Temp ~ CO ₂ + TSI anomaly + VEI count
R ² : 0.936
Adj R ² : 0.933

Results and discussions

- Our regression analysis shows a strong positive relationship between atmospheric CO₂ and global temperature anomalies (R² = 0.923), indicating CO₂ alone explains most of the warming trend.
- Adding solar irradiance and volcanic activity increases explanatory power slightly (R² = 0.936) but with minor contributions compared to CO₂.
- ANOVA confirms the extended model significantly improves fit (p = 0.004), reinforcing the dominant role of anthropogenic CO₂ in recent global warming.

Conclusion

The analysis clearly indicates that rising atmospheric CO₂ levels are the primary driver of the observed global surface temperature increase over the past decades. While solar irradiance and volcanic activity exhibit minor effects, their influence is small compared to the strong and consistent impact of anthropogenic CO₂ emissions. These findings support the consensus that human-made greenhouse gas emissions are the dominant cause of recent global warming, highlighting the urgency for mitigation efforts.

References

- Mauna Loa CO₂ Data (NOAA/ESRL)
- Berkeley Earth Land Temperature Data R. Rohde et al., "Berkeley Earth Surface Temperature Data," Berkeley Earth, 2013. [Online]. Available:
- HadSST Ocean Temperature Data (Met Office Hadley Centre)
- Total Solar Irradiance Data (PMOD/WRC)
- Volcanic Eruption Index (Smithsonian Institution Global Volcanism Program)
- Aerosol Optical Depth Data (NASA GISS)



Github