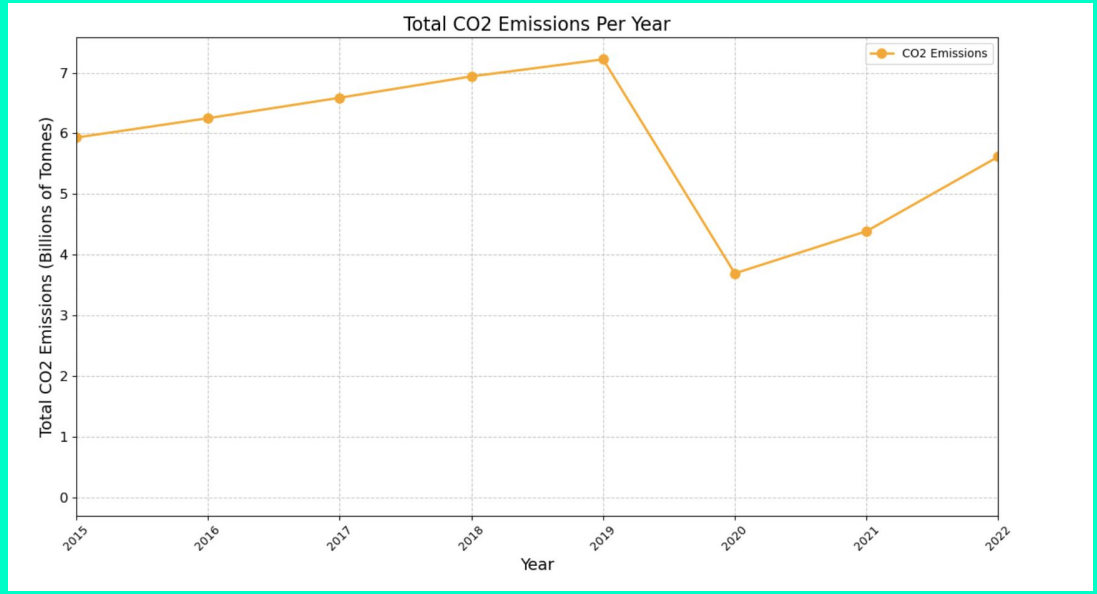
ANALYTICAL DIVE INTO CARBON EMISSIONS FROM AIRPLANES

By Anand Jayashankar

What have carbon emissions looked like the past few years?

```python
import pandas as pd
import matplotlib.pyplot as plt

# Load the Excel file
file_path = "/Users/anand/Downloads/Natural_Science_Dataset.xlsx"
excel_data = pd.ExcelFile(file_path)

# Load data from the relevant sheet
sheet_data = pd.read_excel(excel_data, sheet_name='Sheet 1 - AIRTRANS_CO2_17062024')

# Replace '#' with NaN and convert the 'Value' column to numeric, forcing errors to NaN
sheet_data['Value'] = pd.to_numeric(sheet_data['Value'].replace('#', pd.NA), errors='coerce')

# Drop rows where 'TIME' is NaN
sheet_data = sheet_data.dropna(subset=['TIME'])

# Convert TIME to string to ensure we can filter properly
sheet_data['TIME'] = sheet_data['TIME'].astype(str)

# Filter out rows where 'TIME' does not represent a full year
sheet_data = sheet_data[sheet_data['TIME'].str.match(r'^\d{4}$')]

# Drop any remaining rows with NaN values after filtering
sheet_data = sheet_data.dropna(subset=['TIME'])

# Convert TIME to a string format, and extract only the year
sheet_data['YEAR'] = pd.to_datetime(sheet_data['TIME'], errors='coerce').dt.year

# Group by year and sum the emissions
total_emissions_per_year = sheet_data.groupby('YEAR')['Value'].sum().reset_index()

# Convert the emissions values to billions for better readability
total_emissions_per_year['Value'] = total_emissions_per_year['Value'] / 1e9

plt.figure(figsize=(12, 7))
plt.plot(total_emissions_per_year['YEAR'], total_emissions_per_year['Value'],
         marker='o', color='orange', linestyle='-', linewidth=2, markersize=8, label='CO2 Emissions')

# Add titles and labels
plt.title('Total CO2 Emissions Per Year', fontsize=16)
plt.xlabel('Year', fontsize=14)
plt.ylabel('Total CO2 Emissions (Billions of Tonnes)', fontsize=14)

# Customize ticks
plt.xticks(total_emissions_per_year['YEAR'].unique(), rotation=45)
plt.xlim(2015,2022)
plt.yticks(fontsize=12)
plt.grid(linestyle='--', alpha=0.7)

# Add a legend
plt.legend()

# Show the plot
plt.tight_layout()
plt.show()
```

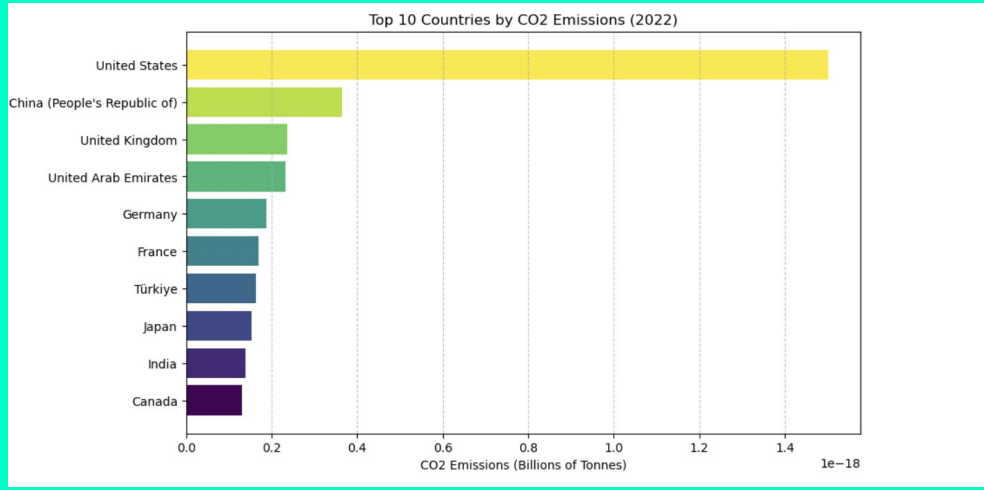


Which countries are contributing the most?

```
# Load the Excel file
file_path = "/Users/anand/Downloads/Natural_Science_Dataset.xlsx"
excel_data = pd.ExcelFile(file_path)

# Load data from the relevant sheet
sheet_data = pd.read_excel(excel_data, sheet_name='Sheet 1 - AIRTRANS_CO2_17062024')

# Filter the dataset for the year 2022
emissions_2022 = sheet_data[sheet_data['TIME'] == 2022]

# Group by country and sum the emissions
top_emissions_2022 = emissions_2022.groupby(['Country'])['Value'].sum().reset_index()

# Sort in descending order to get the top emitters
top_emissions_2022 = top_emissions_2022.sort_values(by='Value', ascending=False).head(10)

# Display the result
print(top_emissions_2022)
```

```
                         Country         Value
173                United States  1.500890e+09
33   China (People's Republic of)  3.642133e+08
172               United Kingdom  2.358791e+08
171         United Arab Emirates  2.331076e+08
60                       Germany  1.883930e+08
57                        France  1.700685e+08
168                      Türkiye  1.629893e+08
79                         Japan  1.523236e+08
71                         India  1.387203e+08
29                        Canada  1.307103e+08
```

```
import numpy as np

# Divide the emissions values by 1 billion to convert to billions
top_emissions_2022['Value'] = top_emissions_2022['Value'] / 1e9

# Sort data in descending order for better visualization
top_emissions_2022 = top_emissions_2022.sort_values(by='Value', ascending=True)

# Generate a color for each country using a colormap
colors = plt.cm.viridis(np.linspace(0, 1, top_emissions_2022.shape[0]))

# Plotting-Utilized ChatGPT to help me create this graph and to color code it
plt.figure(figsize=(10, 6))
plt.barh(top_emissions_2022['Country'], top_emissions_2022['Value'], color=colors)
plt.xlabel('CO2 Emissions (Billions of Tonnes)')
plt.title('Top 10 Countries by CO2 Emissions (2022)')
plt.grid(axis='x', linestyle='--', alpha=0.7)

# Show the plot
plt.show()
```

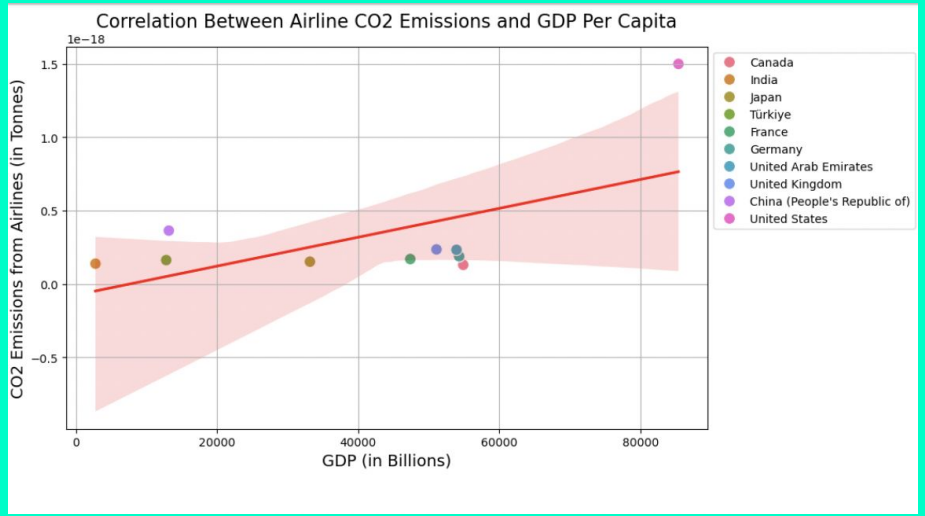


What's the relationship between the carbon emission and economic prosperity?

```python
# GDP per capita data collected manually from World Bank
gdp_data = {
    'Country': ['United States', "China (People's Republic of)", 'United Kingdom', 'United Arab Emirates',
                'Germany', 'France', 'Türkiye', 'Japan', 'India', 'Canada'],
    'GDP': [85373, 13136, 51075, 53916, 54291, 47359, 12765, 33138, 2731, 54866]  # GDP in billions
}

gdp_df = pd.DataFrame(gdp_data)

# Merge the two DataFrames
merged_df = pd.merge(top_emissions_2022, gdp_df, on='Country', how='inner')
```

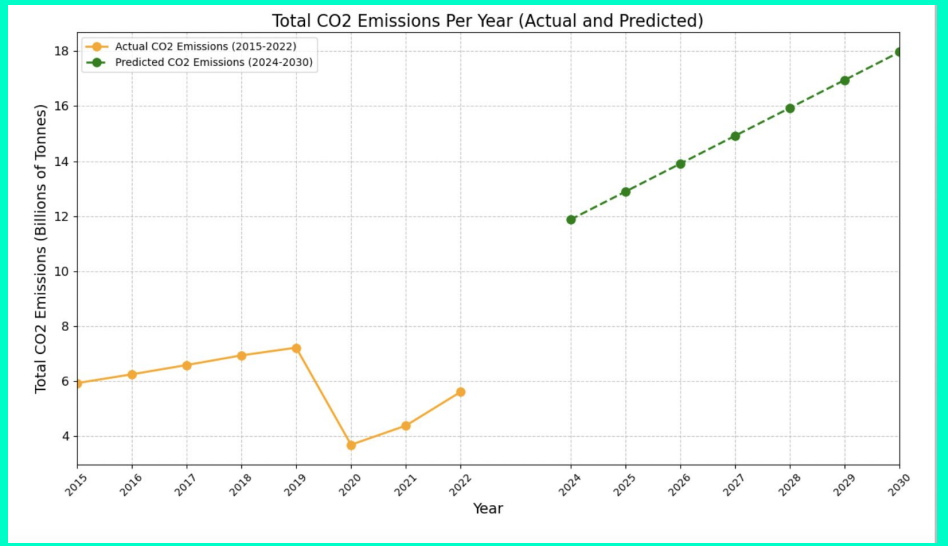
	Country	Value	GDP
0	Canada	1.307103e-19	54866
1	India	1.387203e-19	2731
2	Japan	1.523236e-19	33138
3	Türkiye	1.629893e-19	12765
4	France	1.700685e-19	47359
5	Germany	1.883930e-19	54291
6	United Arab Emirates	2.331076e-19	53916
7	United Kingdom	2.358791e-19	51075
8	China (People's Republic of)	3.642133e-19	13136
9	United States	1.500890e-18	85373

```python
import matplotlib.pyplot as plt
import seaborn as sns

# Scatter plot with a distinct color palette—Utilized ChatGPT
plt.figure(figsize=(10, 6))
palette = sns.color_palette("husl", len(merged_df))  # or use "Set1" or "coolwarm"
sns.scatterplot(data=merged_df, x='GDP', y='Value', hue='Country', palette=palette, s=100)

# Fit a regression line
sns.regplot(data=merged_df, x='GDP', y='Value', scatter=False, color='red')

plt.title('Correlation Between Airline CO2 Emissions and GDP', fontsize=16)
plt.xlabel('GDP (in Billions)', fontsize=14)
plt.ylabel('CO2 Emissions from Airlines (in Tonnes)', fontsize=14)
plt.grid()
plt.legend(loc='upper left', bbox_to_anchor=(1, 1))  # Adjust legend location
plt.show()
```



Carbon Emission Future Projection

```python
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
import numpy as np

# Load the historical CO2 emissions data
historical_data = pd.read_excel("/Users/anand/Downloads/Natural_Science_Dataset.xlsx", sheet_name='Sheet 1 - AIRTRANS_CO2_


# Filter out necessary columns and convert 'Value' to numeric, replacing '#' with NaN
historical_data['Value'] = historical_data['Value'].replace('#', np.nan).astype(float)

# Drop rows with NaN values in 'Value'
historical_data = historical_data.dropna(subset=['Value'])

# Extract the year from 'TIME' and create a new column
historical_data['YEAR'] = pd.to_datetime(historical_data['TIME'], errors='coerce').dt.year

# Group by year and sum the emissions
yearly_emissions = historical_data.groupby('YEAR')['Value'].sum().reset_index()

# Prepare the data for regression
X = yearly_emissions[['YEAR']]  # Feature
y = yearly_emissions['Value']  # Target

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Train a linear regression model
model = LinearRegression()
model.fit(X_train, y_train)

# Make predictions for the next few years
future_years = pd.DataFrame({'YEAR': np.arange(2024, 2031)})  # Predict for 2024 to 2030
predictions = model.predict(future_years)

# Create a DataFrame for the predictions
predicted_emissions = pd.DataFrame({'YEAR': future_years['YEAR'], 'Predicted Value': predictions})
# Display only the relevant columns for predictions
predicted_emissions = predicted_emissions[['YEAR', 'Predicted Value']]
print(predicted_emissions)
```



What does this all mean?

We have to cut carbon emissions

- Adhere to Global Aviation Emissions Pact
  - Use of low-carbon alternative fuels
- Continuing to improve efficiency of aircrafts
- Government spending on interventions to offset aviation carbon emissions

Thank you for your time!