# Global Warning

A study of global carbon dioxide emissions over time

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# Introduction

- Global Warming
  - Shift in weather patterns due to an increase in global emissions
  - Increase in production of greenhouse gases - namely carbon dioxide
- Our goal
  - Explore how carbon dioxide emissions have changed over time
    - Which countries contribute the most?
    - Which continue to increase over time? Why?
- What does this mean for our future?

# The Data

- Raw dataset found on Kaggle
- Time series data set ranging from 1751-2017
- 17946 observations in the raw dataset
- Dataset is comprised of observations under the variable name 'Entity'
  - These Entities are comprised of individual countries, territories, continents, and others
- The main metric being shown in the data set is tonnes of emissions (Co2)

# Experimental Design - Data Cleaning

- Changed variable names
- Created different data sets with dropped entities
  - We dropped soe territories, continents, and other entities for some specific datasets
- Ran descriptive statistics for the original data set
  - Mean year of data 1962, Median year 1974
- Removed non informational data
  - Years with unreported carbon emission years
  - Entities that were a group of countries
- Created new columns for Year of Year percent change, and total percentage of the world emissions for that entity in the given year

# **Experimental Design - Queries**

- Which year had the greatest increase in emissions?
  - Using year-over-year percent change to help with this
- When did countries decrease their emissions?
  - What trends can be seen and what does this tell us
- In what instances did countries have net carbon emission of 0 during modern times?
- Which portion of Co2 emissions came from international transport?
- What are the continental emissions figures over the given time interval?

# Experimental Design - Testing

- Unit testing
- Print statements
- General data set examination

# Experimental Design - Visualization

- Pie chart of global emissions for 2017
- Graph of total world emissions from 1751-2017
- The effects of World War II on emissions for the top 5 emission producing nations
- Plot of Continental emissions over time 1940-2017
- Plots for individual countries significant events
  - Syrian Civil War
  - Lebeneese Civil War
  - North Korea nuclear search
- Plot for global trade over time

# Beyond the Original Specifications

- Why is carbon dioxide emissions important to global warming
  - Carbon dioxide ppm has increased from 280 ppm to 400+ ppm
  - Predict what might happen in the future
  - How can everyday events lower carbon emissions
    - Removing single use plastic
    - Using carbon emissions free travel for work
    - Showering 2 minutes less

# **Beyond the Original Specifications**

- Project framework
  - Main (analysis) file
  - User interface (visualization tool)
  - Functions file
  - Testing file
- User interaction
  - Engagement
  - Understanding (saddening fun facts!)
  - Ability to save and export results of queries

```
246 observations found.

--Filters--
Countries:
United States, Canada, Brazil, India, China, Russia
Years:
1975 to 2015

[1] Filter by Country
[2] Filter by Year
[3] Clear Filters
[4] Produce Visualization
[5] Export Data
[6] Learn about emissions in context

[0] Quit

Please make a selection:
```
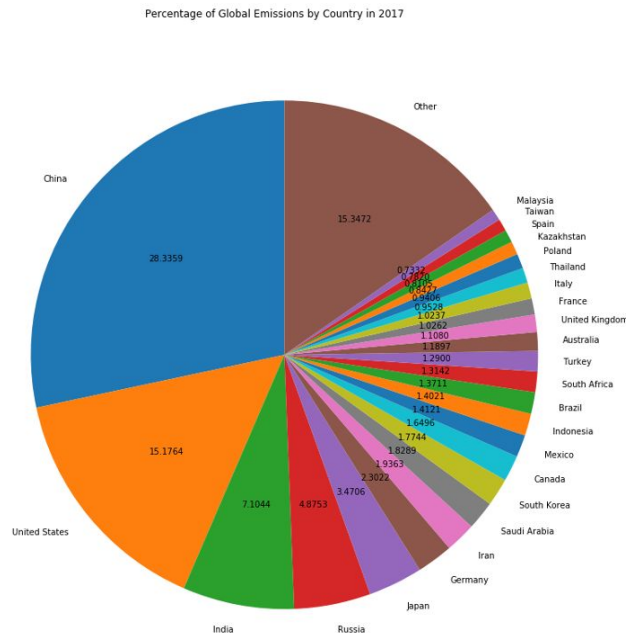
# Results - Percent of Global Emission by Country

- Uneven distribution amongst countries
- China, India, and US account for half of total global emissions

Percentage of Global Emissions by Country in 2017

# Results - Year over Year Decrease in Emissions

- In 2009, nearly half of the world's countries reported decreased annual emissions
    - The Global Financial Crisis began in the middle of 2007 and lasted until early 2009
    - Undoubtedly had a significant impact on economies around the world
    - Could other significant global events impact our data?

# Results - Year over Year Doubling in Emissions

- In 1950, 26 different countries reported a YoY increase of 100% or more
  - Not significant event immediately comes to mind
  - Relatively soon after the second World War
  - Post war economic recovery and rapid industrialization?

# Results - Globally Significant Events

- Major dip in 1929 from Great Depression

- Strong recovery through 1944

- End of WWII creates another strong dip

- Drastic decline for Germany vs mild for U.S
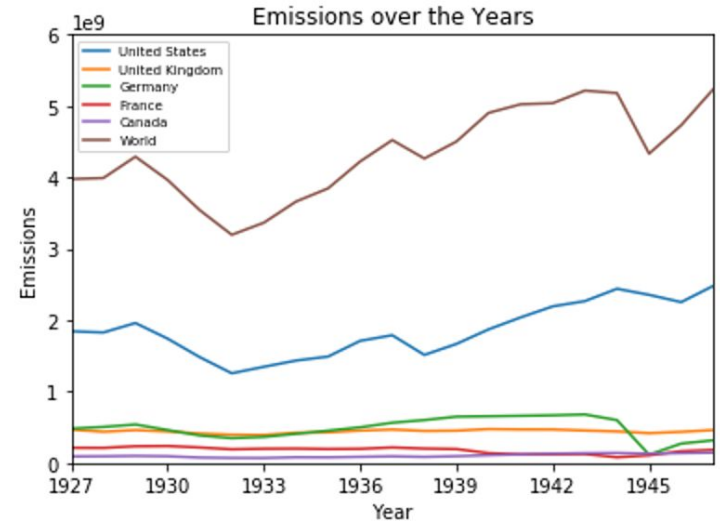
# Results - Continental Emissions

- Major increase starting late 50's early 60's

- Significant drop in Europe in the early 90's

  - Possibly due to the formation of European Union

- Asia and Pacific countries responsible for nearly twice

  as much as next highest



Continental Emissions over the Years
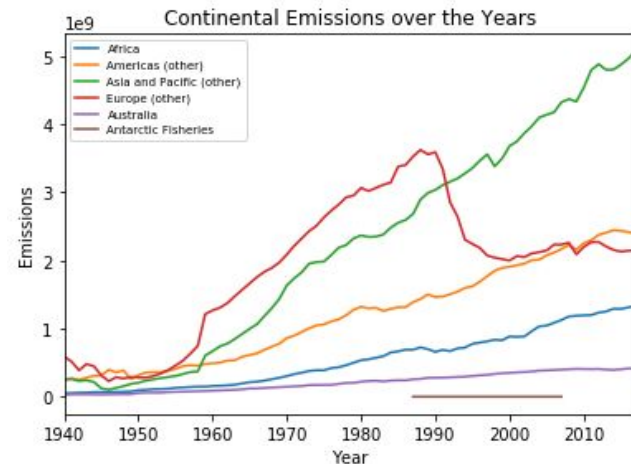
# Results - International Transport

- In 2017, International Transport responsible for

  ~ 3% of global emissions

  - 6th highest contributor globally

    - Just ahead of the entire country of Germany

# Results - Carbon Dioxide Emissions vs everyday human production

- Logistic fit of the last 50 years of total world CO2 emissions:

    - Estimated total emissions = $8.75 * 10^{12}$ * ln(year) - $6.62 * 10^{12}$

    - Estimated year = e^((estimated total emissions + $6.62 * 10^{12}$) / $8.75 * 10^{11}$)

- Estimated "safe limit" of 100 billion metric tons of CO2 emissions annually

- Estimate year to reach threshold = 2174

- Average human

    - Produces 50 kg of plastic waste per year = 0.3 metric tons of carbon dioxide[1]

    - Drives 32 miles round trip for work 240 days of the year = 3.16 metric tons of carbon dioxide[2]

    - Showers for approximately 8 minutes[2]

        - 2 minutes = 0.155 metric tons of carbon dioxide

# Results - Carbon Dioxide Emissions vs everyday human production

- Total CO2 emissions in the US in the year 2017 was 5.3 billion metric tons
  - One individual
    - 17.6 billion years of removing single use plastic
    - 1.7 billion years of emission free work travel
    - 34 billion years of showering 2 fewer minutes
  - The whole population of the US
    - 53.6 years of removing single use plastic
    - 5.1 years of emission free work travel
    - 103.6 years of showering 2 fewer minutes

# Results - Carbon Dioxide Emissions vs everyday human production

- CO2 emissions in the world in the year 2017 was 36.2 billion metric tons
  - One individual
    - 120.5 billion years of removing single use plastic from their lives
    - 11.5 billion years of emission free work travel
    - 233.1 billion years of showering 2 fewer minutes
  - The whole population of the US
    - 367.4 years of removing single use plastic from their lives
    - 34.9 years of emission free work travel
    - 710.5 years of showering 2 fewer minutes

# Results - Carbon Dioxide Emissions vs everyday human production

- Did we do better in previous years?

- CO2 emissions in the US in the year 1950 was 2.5 billion metric tons
  - One individual
    - 8.5 billion years of removing single use plastic
    - 803 million years of emission free work travel
    - 16.3 billion years of showering 2 fewer minutes
  - The whole population of the US
    - 25.8 years of removing single use plastic
    - 2.4 years of emission free work travel
    - 49.8 years of showering 2 fewer minutes

# Testing - Sanity Check

- Print statements

- Checking exports

- Visuals outputting to screen

- Testing all flow paths for user interface component

# Testing - Unit Testing

- Subset by Year function
  - Handling a single year
  - Testing output for year not in range
  - Testing start year for various subsets

```python
class SubsetYearTestCase(unittest.TestCase):

    def test_is_subset_year_handling_single_year(self):

        sampledf = subset_by_year(data_countries, 2005)
        years_included = sampledf['Year'].unique()
        # Test
        self.assertEqual(years_included, [2005])
```

- Subset by Entity function
  - Testing if output entity is correct with various entities

```python
class SubsetEntityTestCase(unittest.TestCase):

    def test_is_subset_entity_working(self):

        sampledf = subset_by_entity(data_countries, 'Ecuador')
        entities_included = sampledf['Entity'].unique()
        # Test
        self.assertEqual(entities_included, ['Ecuador'])
```

# Conclusion

- **Findings**
  - Factors most influential to emissions.
  - Better understanding of current state of emissions.
    - Comparison of countries
    - Historical Context
  - Context for scale and severity of the problem.
- **Expanding the Scope**
  - Incorporate other factors
    - Population and Demographics
    - Economics
  - Expand visualizations and user input

# Conclusion

- **Growth as Data Scientists**
  - Experience working with data at (medium) scale.
  - Designing for users and organizing code.
  - Planning, validation, testing.
  - Starting point for complex issue.
  - Got us thinking and theorizing!

# Project Repository

https://github.com/bmfeciura/cs5010-project

# Sources

Data:

https://www.kaggle.com/yoannboyere/co2-ghg-emissionsdata

[1] Pamuła, Hanna. "Plastic Footprint Calculator." *Check Your Environmental Impact*, Omni Calculator, 16 May 2019, www.omnicalculator.com/ecology/plastic-footprint.

[2] Harris, David. "How Far Do Americans Drive to Work on Average?" *It Still Runs*, 10 Jan. 2019, itstillruns.com/far-americans-drive-work-average-7446397.html.

[3] Lindberg, Sara. "Shower Time: How Long to Take and Are Longer Showers Better?" *Healthline*, Healthline Media, 20 May 2020, www.healthline.com/health/shower-time.