

# Global CO<sub>2</sub> Emissions, Storms, and Temperatures

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# Initial Questions

1. What is the distribution of CO2 emissions by continent/region?
2. Which countries are highest in carbon emissions, has this changed within recent years?
3. How has CO2 emissions changed in the top 5 countries over time? As GDP increases or decreases does this impact CO2 emissions?
4. What is the correlation between different fossil fuel sources and other factors with CO2 emissions?
5. What are the most consumed energy types and changes in energy consumption patterns in the United States?
6. What is the Energy Intensity Per Capita and by GDP of Top 5 CO2 emission producing countries?
7. What is the overall trend of emissions in relation to severe weather events over a certain period of time? What types of storms are most affected?
8. How does increase or decrease in storms affect overall damage caused by storms to property? To crops?
9. How does temperature change over time and how does it relate to carbon emissions?

# Data Sources

Andrew, R. & Peters, G. (2022). The Global Carbon Project's Fossil CO2 Emissions Dataset, Version 27. Retrieved January 13, 2023 from <https://doi.org/10.5281/zenodo.7215364>.

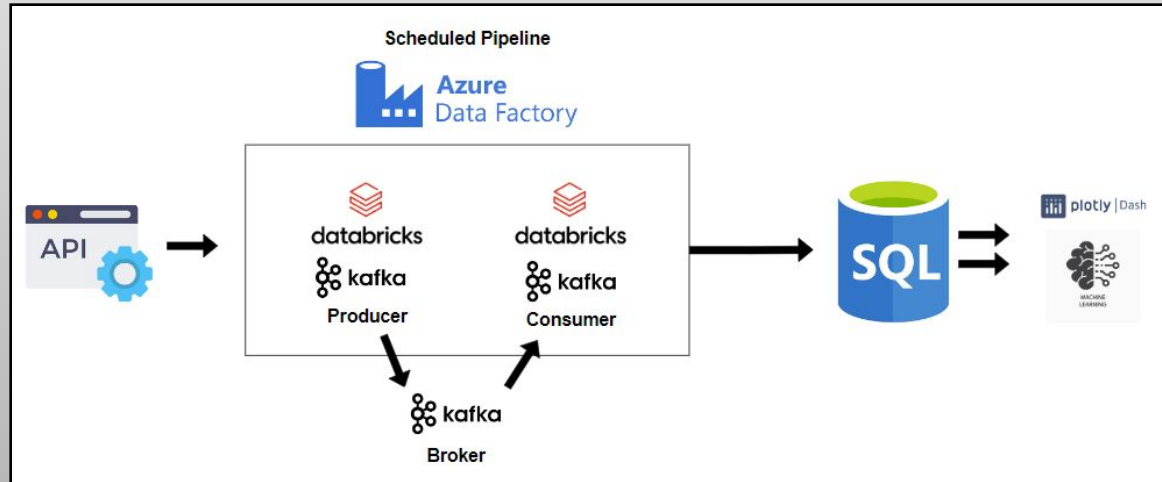
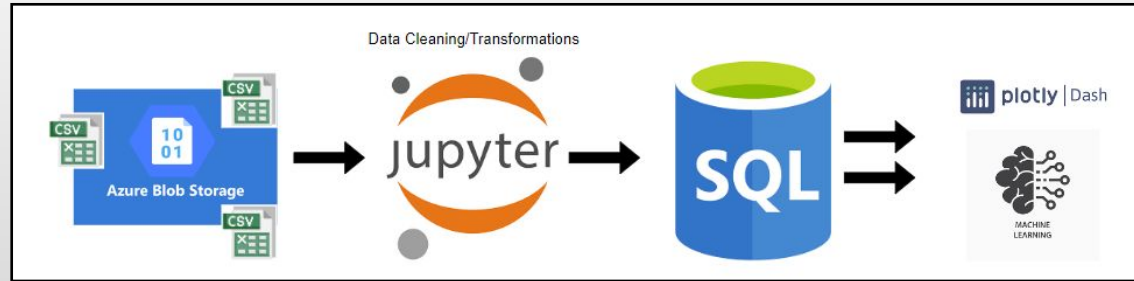
Global-warming.org. (2023) Daily global seasonal cycle and trend value, Version 1. Retrieved January 18, 2023 from <https://global-warming.org/api/co2-api>.

NOAA. (2020, December). Storm Events Database, Version 3.1. Retrieved January 13, 2023 from <https://www.ncei.noaa.gov/pub/data/swdi/stormevents/csvfiles>.

NOAA. (2022, September). Climate at a Glance: Statewide Average Temperature, Version . Retrieved January 13, 2023 from <https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/time-series>.

Vanous, B. (2021). Countries CO2 Emissions and More, Version 1. Retrieved January 16, 2023 from <https://www.kaggle.com/datasets/lobos/c02-emission-by-countries-growth-and-population>.

# Data Pipeline



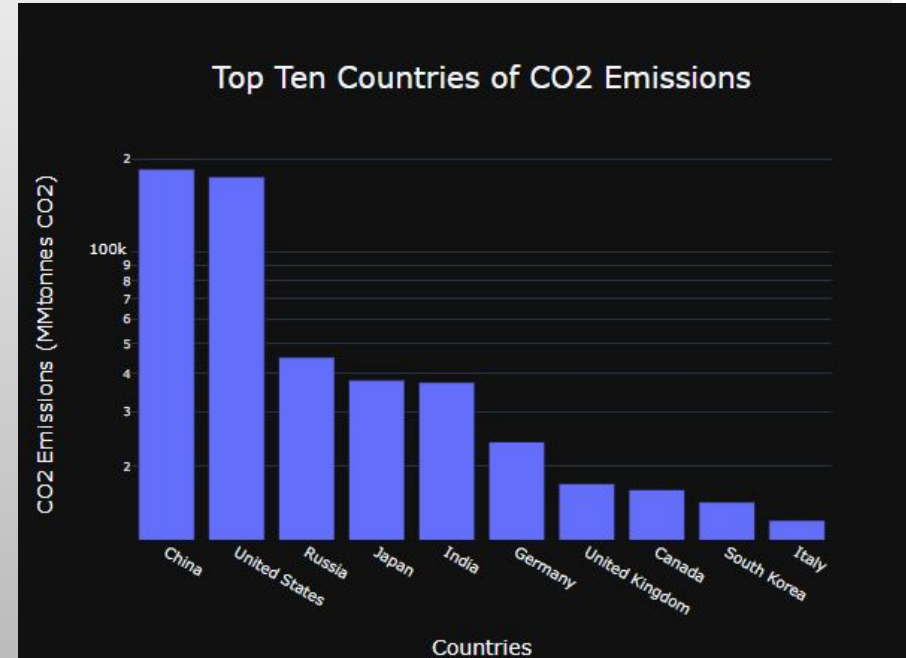
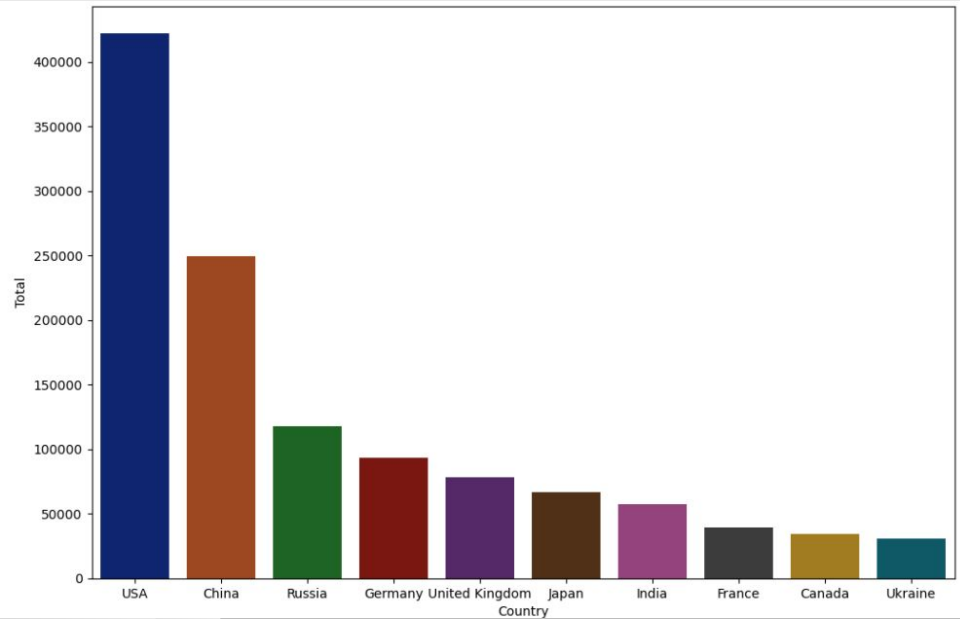
The background features a stylized illustration of industrial infrastructure. In the top left, a grey pipe with black joints runs horizontally and then turns 90 degrees upwards. In the top right, a similar pipe runs horizontally and then turns 90 degrees downwards. In the bottom left, two parallel vertical pipes are shown, with a small blue and orange circular valve on the left one. In the bottom right, a pipe runs vertically and then turns 90 degrees to the right. Grey, wavy smoke or steam is rising from the pipes and filling the background. The central text is in a bold, dark blue font.

# Carbon Emissions

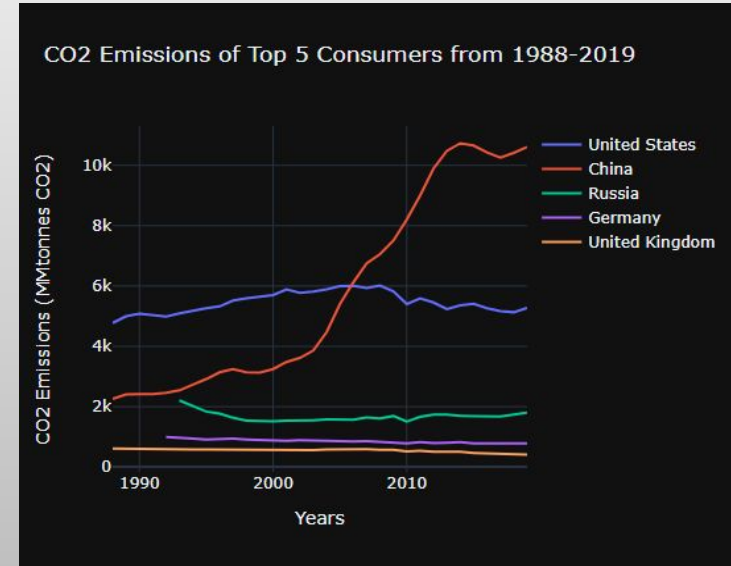
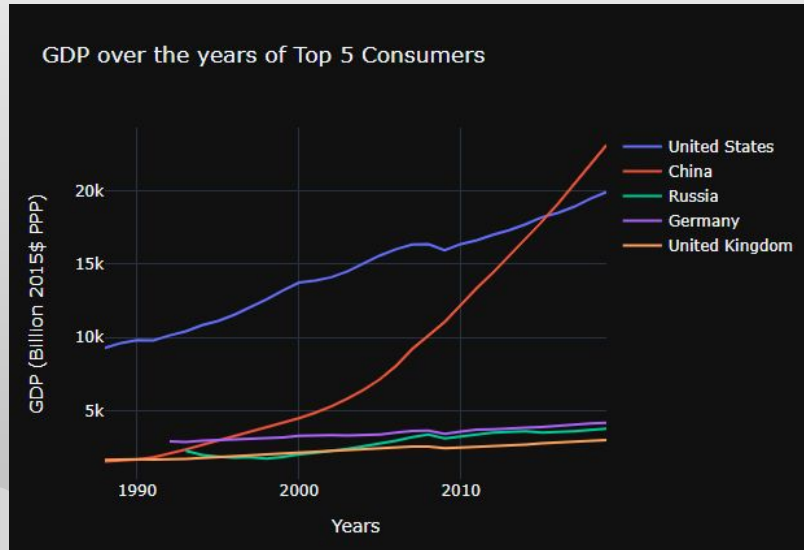
# What is the distribution of CO2 emissions by continent/region?



**Which countries are highest in carbon emissions, has this changed within recent years?**



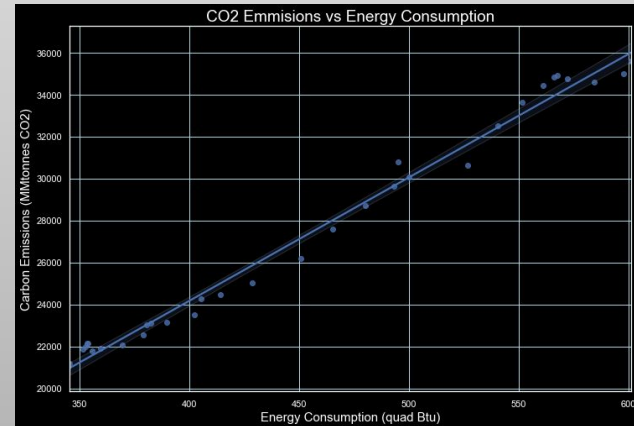
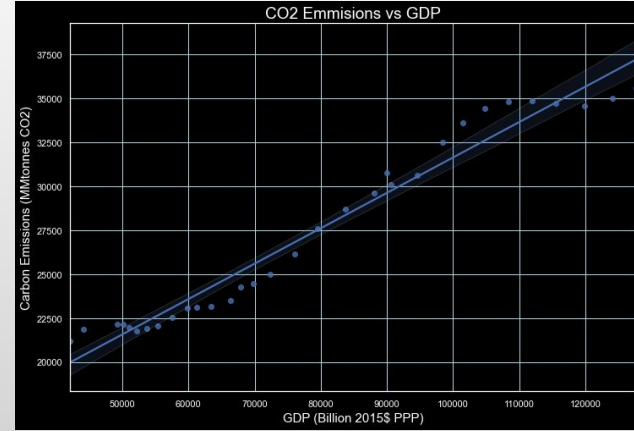
**How has CO2 emissions changed in the top 5 countries over time?**  
**As GDP increases or decreases does this impact CO2 emissions?**

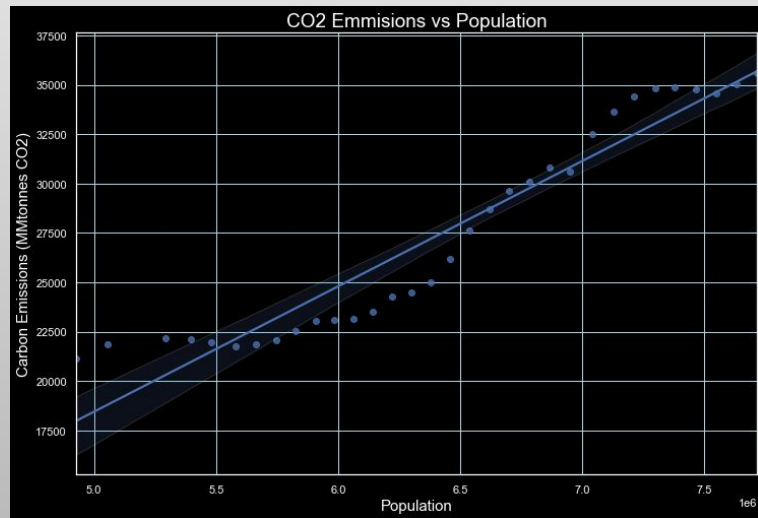
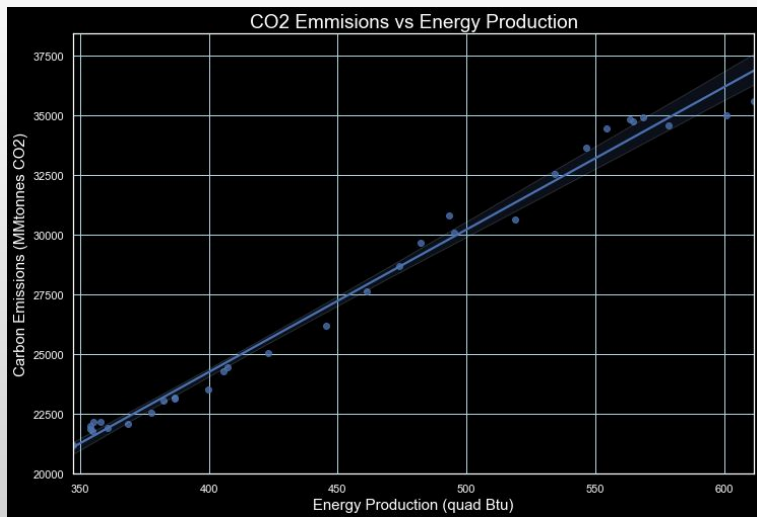




## What is the correlation between different fossil fuel sources and other factors with co2 emissions?

Unnamed: 0	1	1	0.014	0.014	0.035	0.0076	0.044	-0.087	0.013
Year	1	1	0.017	0.017	0.038	0.012	0.042	-0.09	0.016
Energy_consumption	0.014	0.017	1	0.99	0.71	0.7	0.034	0.039	0.99
Energy_production	0.014	0.017	0.99	1	0.71	0.7	0.04	0.043	0.98
GDP	0.035	0.038	0.71	0.71	1	0.96	0.037	0.033	0.68
Population	0.0076	0.012	0.7	0.7	0.96	1	-0.015	0.038	0.67
Energy_intensity_per_capita	0.044	0.042	0.034	0.04	0.037	-0.015	1	0.34	0.029
Energy_intensity_by_GDP	-0.087	-0.09	0.039	0.043	0.033	0.038	0.34	1	0.039
CO2_emission	0.013	0.016	0.99	0.98	0.68	0.67	0.029	0.039	1
Unnamed: 0	Year	Energy_consumption	Energy_production	GDP	Population	Energy_intensity_per_capita	Energy_intensity_by_GDP	CO2_emission	

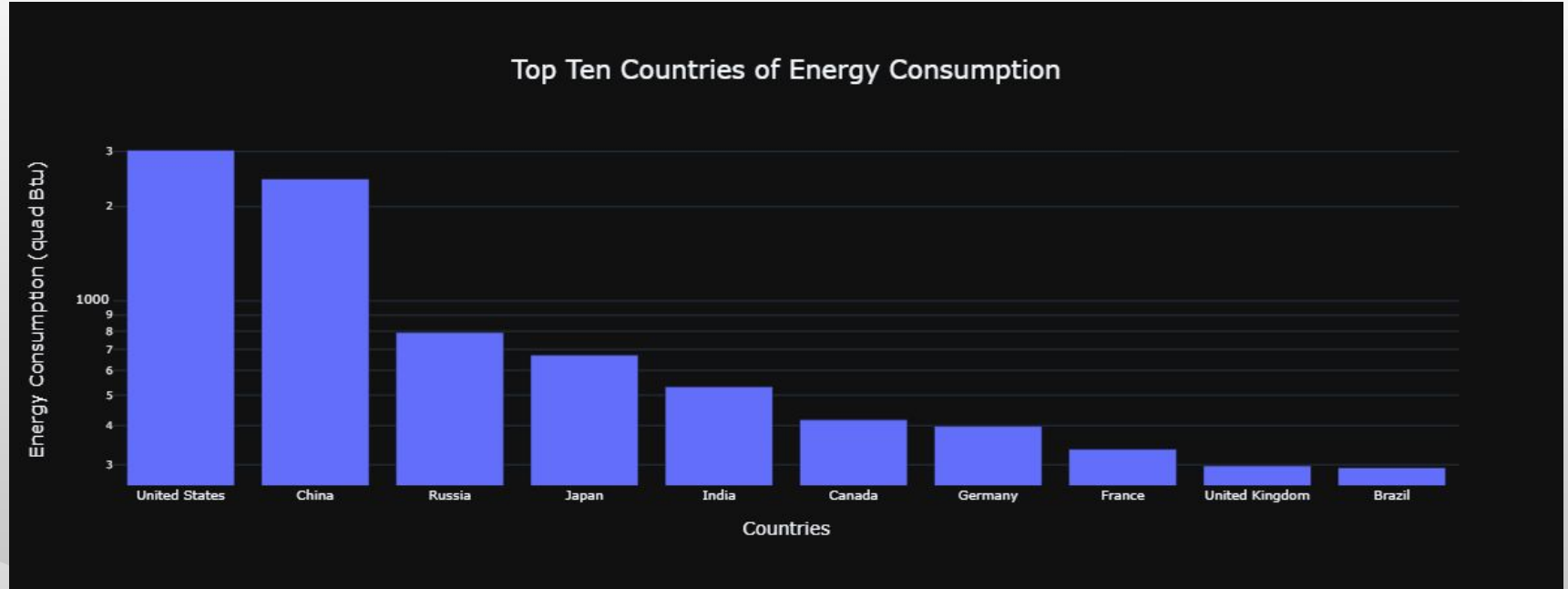






# Energy Consumption

# Who are the Top Ten Countries that consume the most energy?



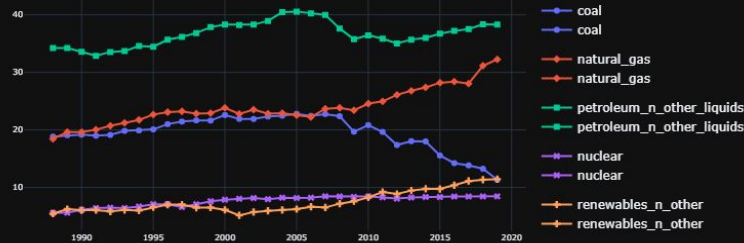
- The leading five nations for both energy consumption and CO2 emission are the same.

# What are the most consumed energy types and changes in energy consumption patterns in the United States?

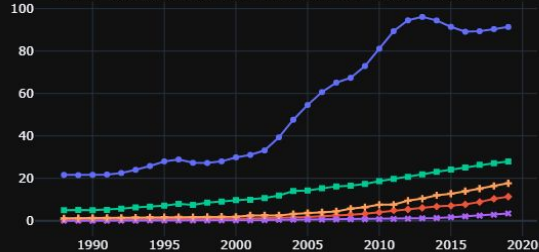
## United States

- Main primary energy sources in the dataset:
  - Fossil fuels: petroleum, natural gas, coal
  - Nuclear energy
  - Renewable sources
- Most widely used energy sources in the US:
  - Petroleum/other liquids
  - Natural gas
- From 2007 to 2019:
  - Coal consumption decreased by nearly 50% reaching the same level as renewables in 2019
- Nuclear energy consumption:
  - Stabilized after reaching a plateau around 2000.

US Yearly Energy Consumption For Each Energy Type



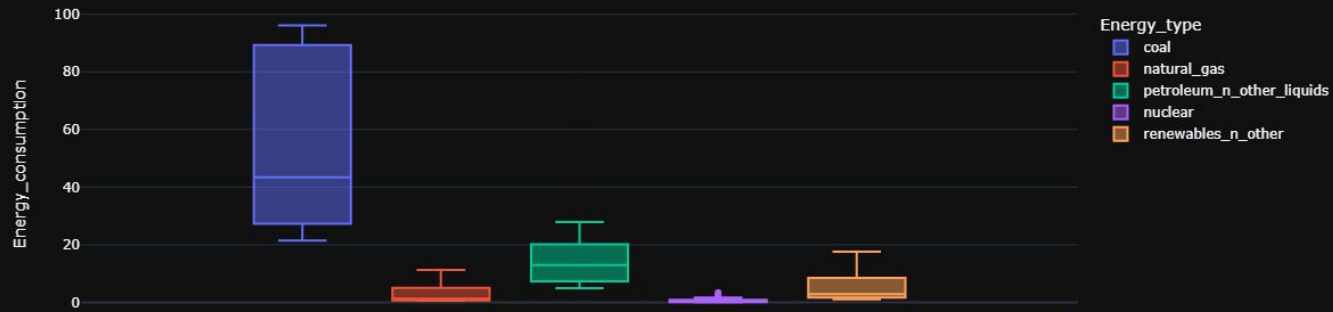
China Yearly Energy Consumption For Each Energy Type



US Total Energy Consumption by Energy Type

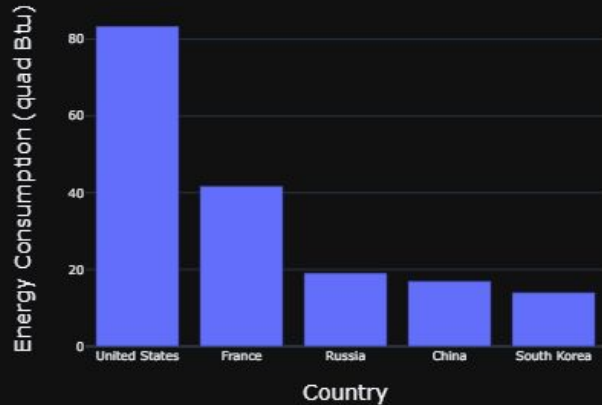


China's Total Energy Consumption by Energy Type

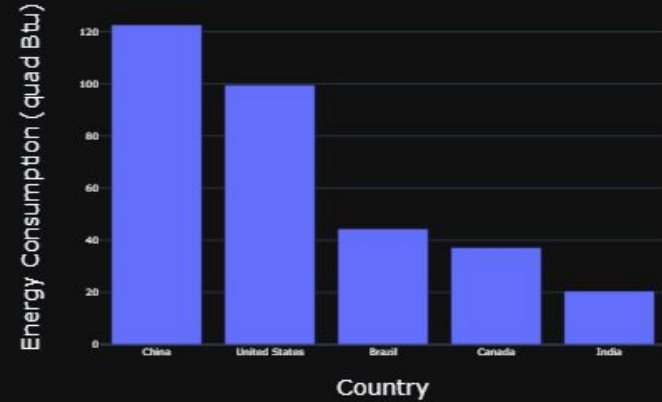


# Who consumed the most “zero emission” energy after 2010?

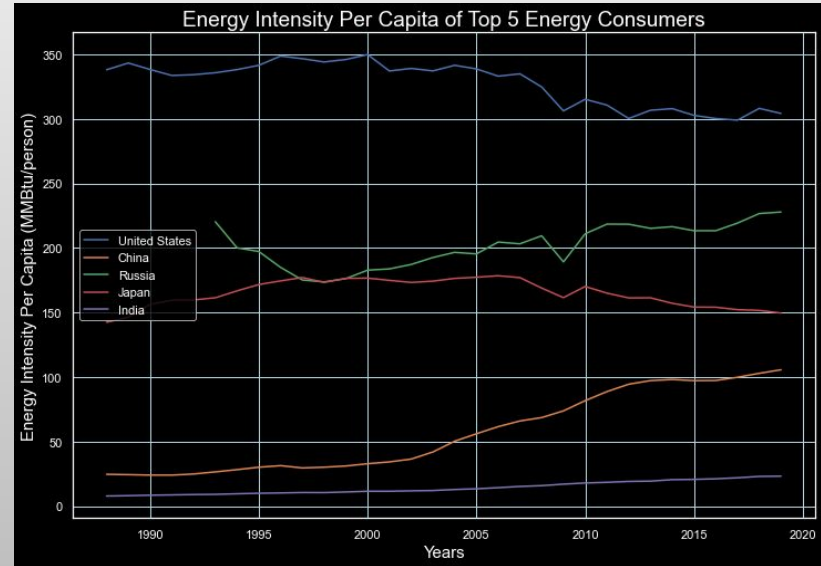
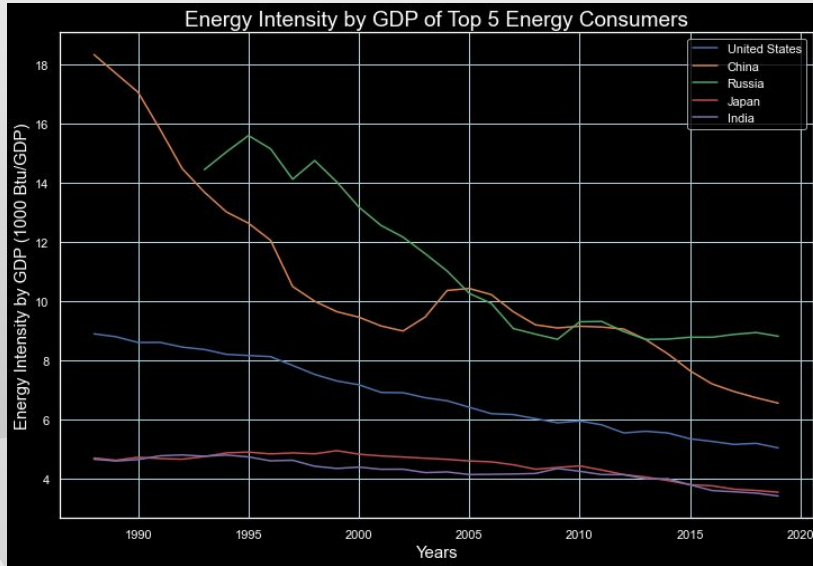
Nuclear (Post 2010)



Renewables (Post 2010)



# What is the Energy Intensity Per Capita and by GDP of Top 5 Energy Consumers?

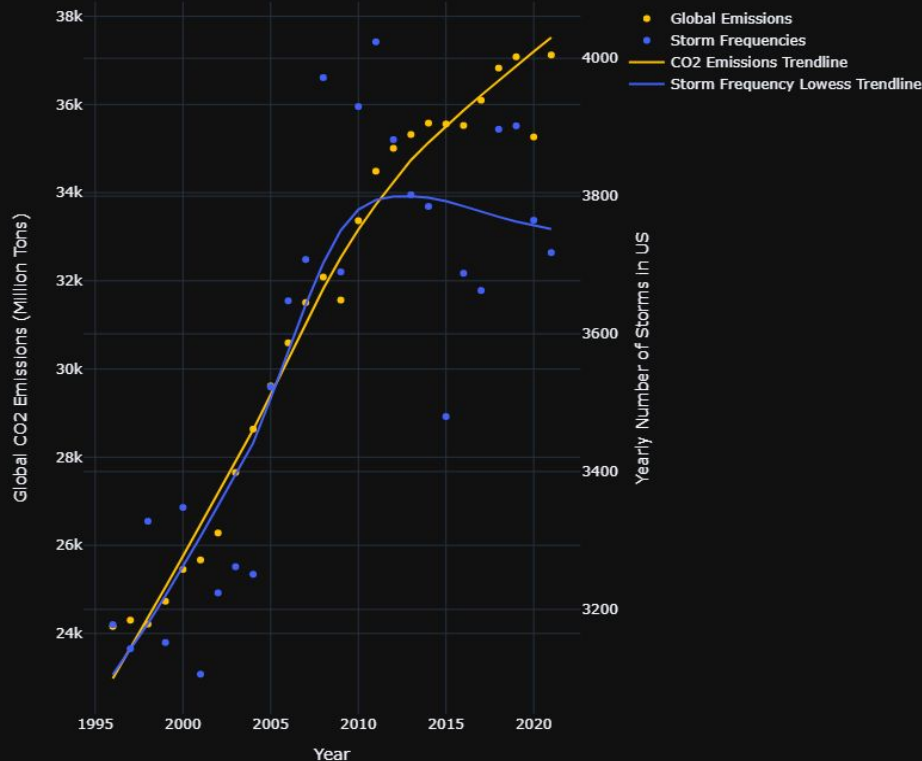




# Storms



Global CO2 Emissions and US Storm Frequencies Together

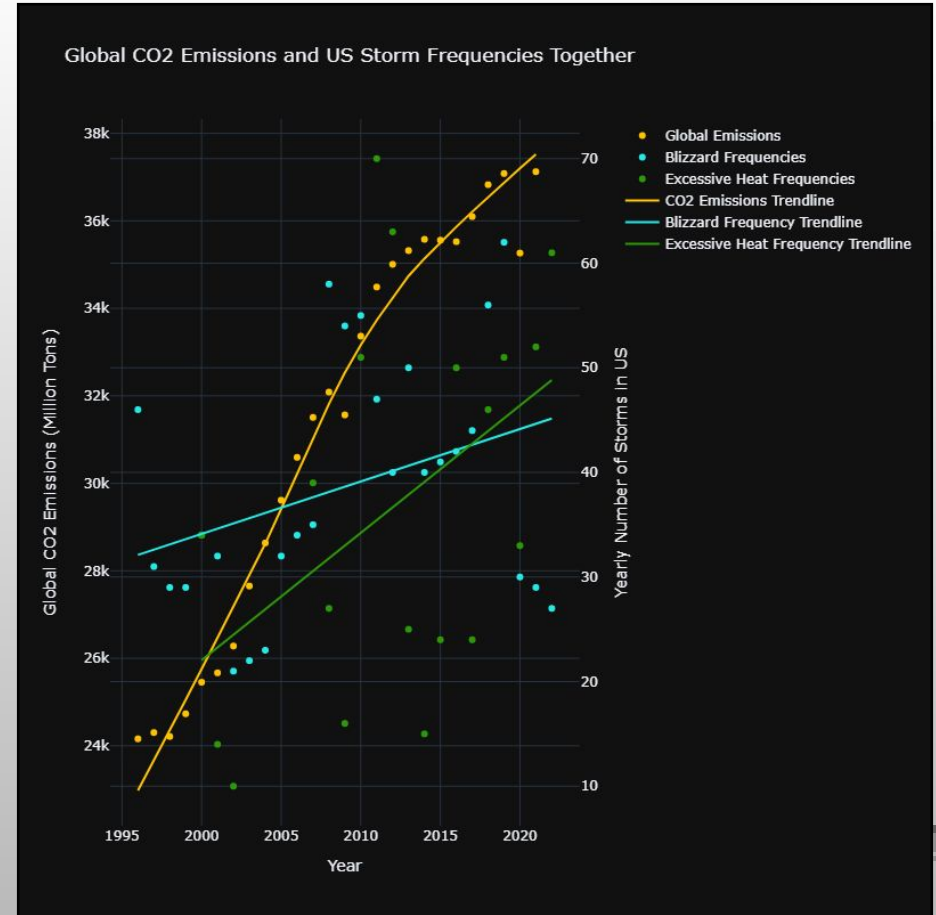
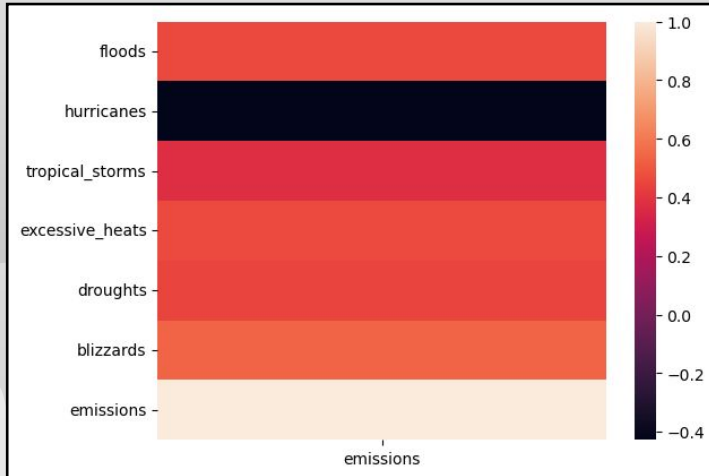


**What is the overall trend of emissions in relation to severe weather events over a certain period of time?**

- $R^2 = 0.851$
- Follow almost identical trend from 1995 to 2010
- Storm trendline levels off after 2010

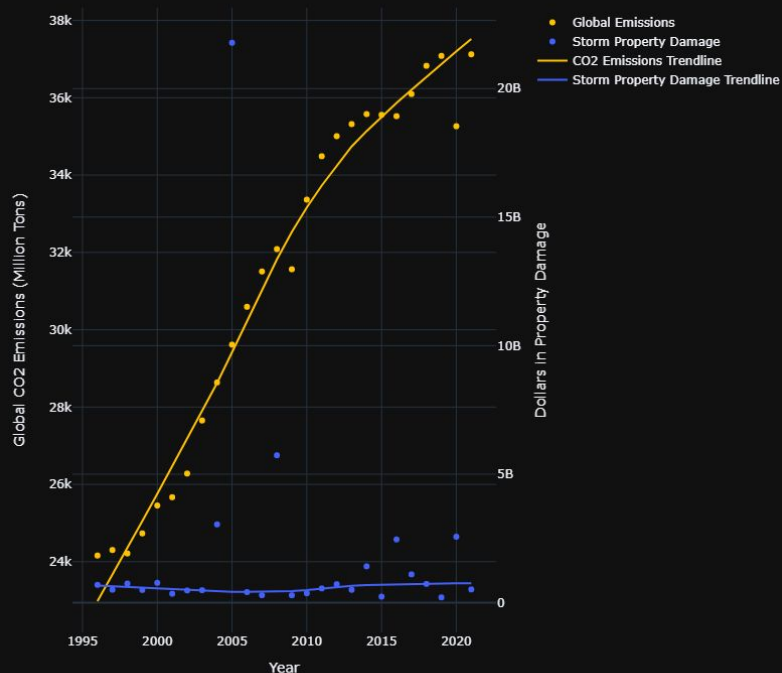
## What types of storms are most affected?

- Looked into floods, hurricanes, tropical storms, excessive heat, drought, and blizzard occurrences

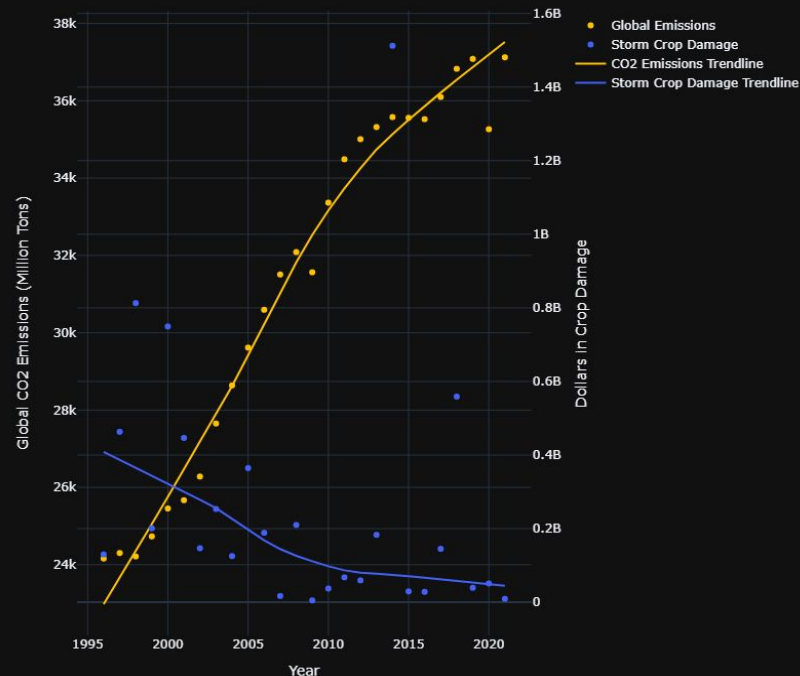


# How does increase in storms affect overall damage caused by storms to property? To crops?

Global CO2 Emissions and Sum of Yearly US Storm Property Damage



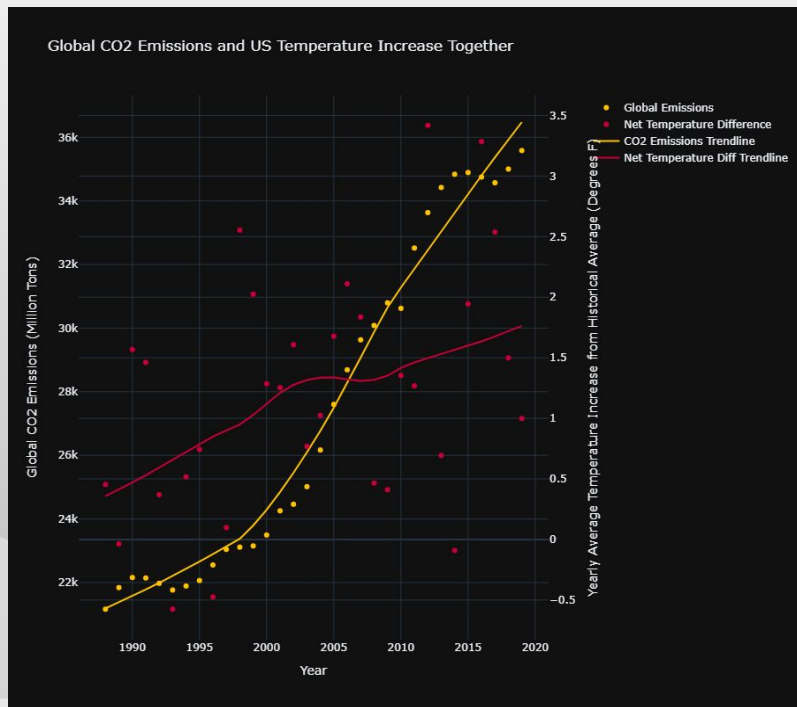
Global CO2 Emissions and Sum of Yearly US Storm Crop Damage



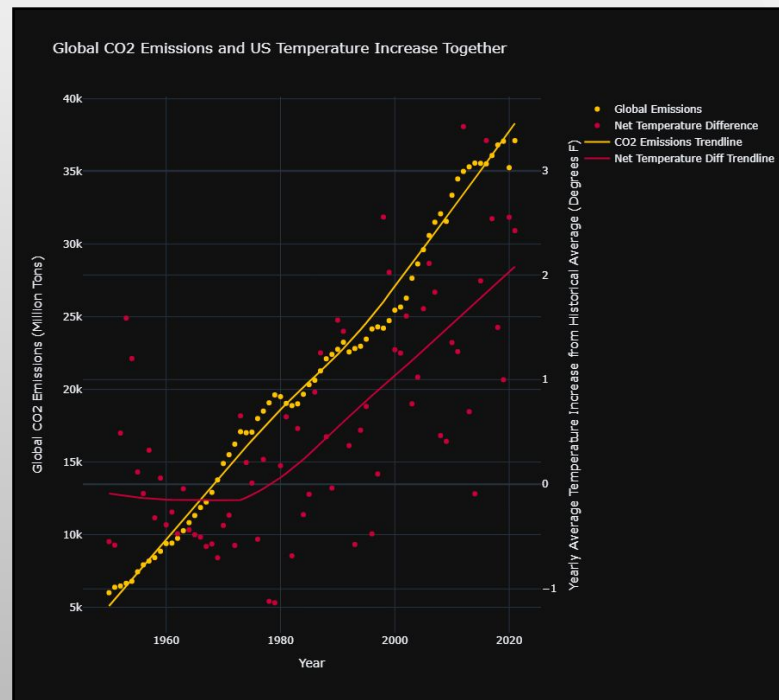


# Temperatures

# How does temperature change over time and how does it relate to carbon emissions?

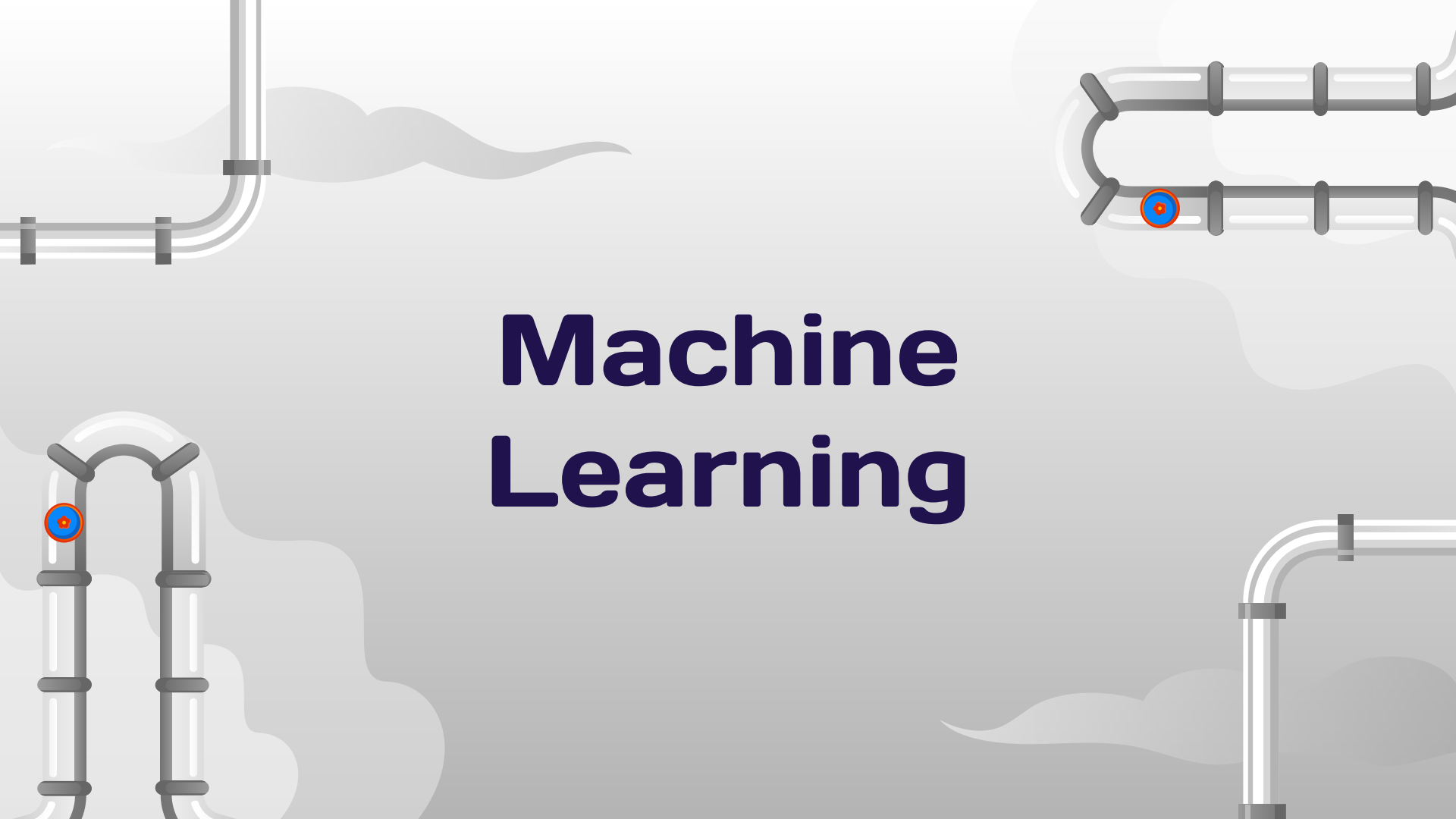


1988-2019  
 $R^2 = 0.391$



1950-2022  
 $R^2 = 0.641$

# Machine Learning



# Setup

- Datasets:
  - NOAA
  - Emissions
- Models used:
  - ZIR
  - XGB
  - SVM
  - LR
- Features:
  - Time series
  - Location
  - Type
  - Emissions
- Target:
  - Damage
  - Temperature differences



# Results

- Performance:
  - XGB
    - $R^2 \sim 0.005$  and  $0.353$
  - ZIR
    - $R^2 \sim 0.005$
  - LR
    - $R^2 < 0$
  - SVM
    - $R^2 \sim 0.382$

