What's in the Wind?

Evaluating Air Quality Trends in the United States Since 1990

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Overview

01. Introduction

Motivation

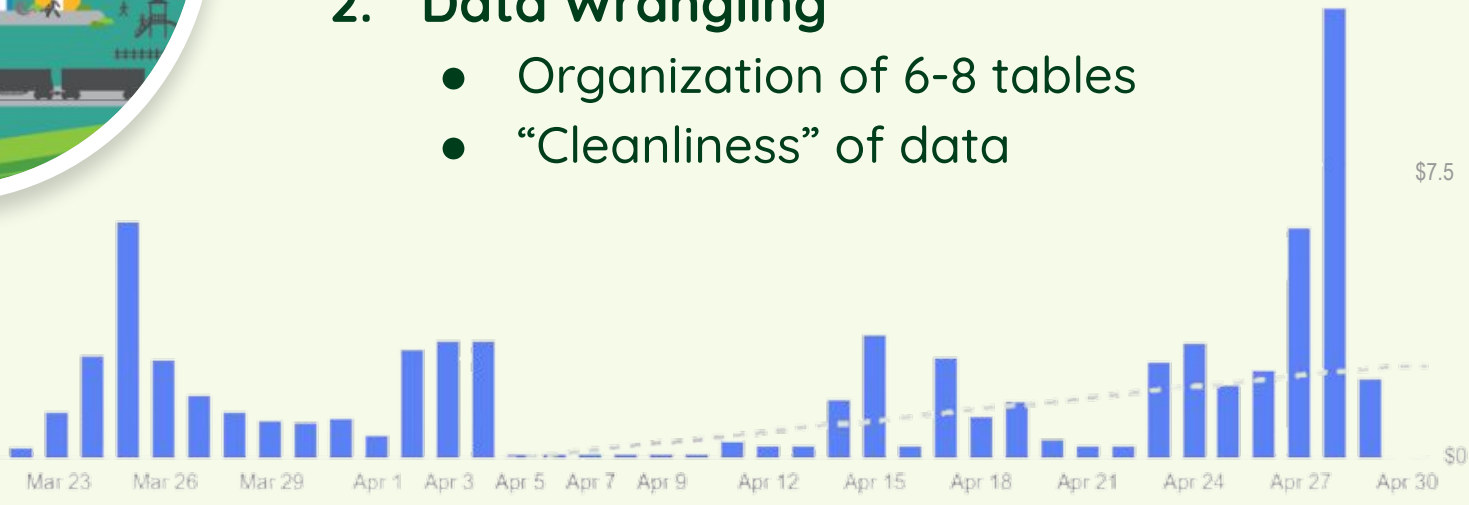
- Identify key drivers of air quality
- Mitigate adverse health outcomes

Data Source

- EPA Historical Air Quality
  - Hosted on BigQuery
- 19.97 GB, 8 tables
  - 6 key pollutants
  - Wind and temperature

01. Challenges

1. **Computing**
   - Main: 4 vCPUs, 32GB RAM
   - 2 Workers: 2 vCPUs, 16GB RAM
2. **Data Wrangling**
   - Organization of 6-8 tables
   - “Cleanliness” of data



02. Summary Statistics

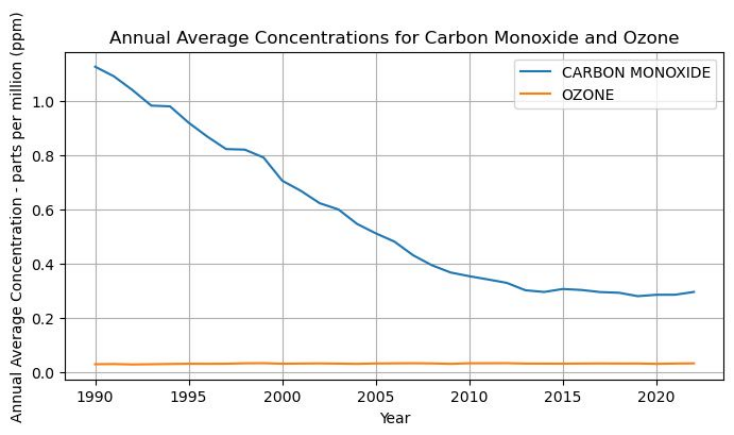
1990-2022

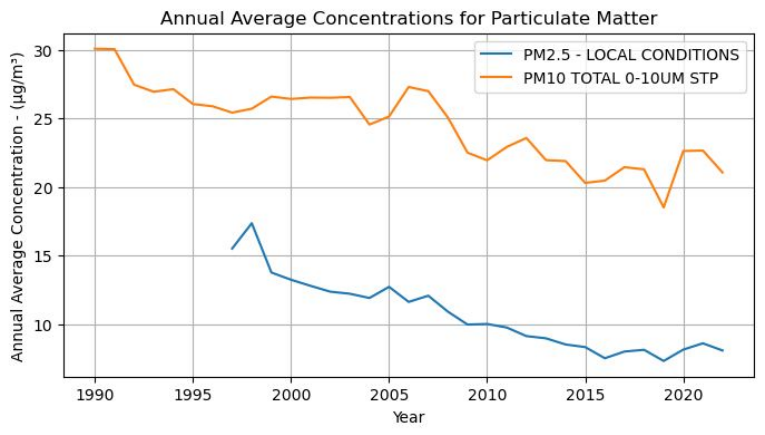
3,327 Sites

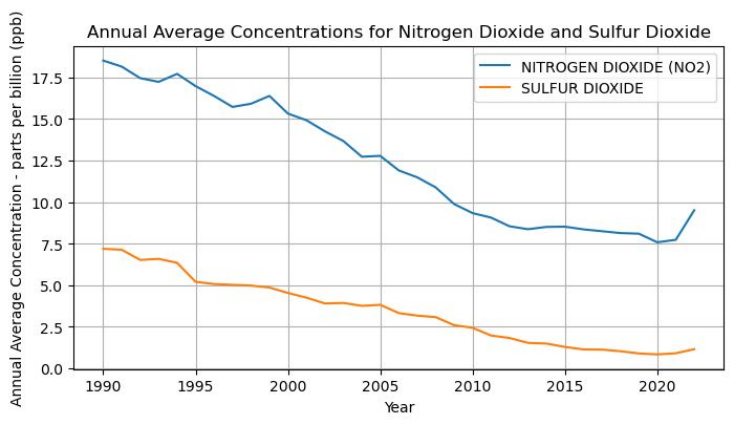
- PM10 has the highest standard deviation
- Ozone has the lowest standard deviation
- Wind speed has a relatively small standard deviation
- Temperature has a relatively large standard deviation

	Carbon Monoxide (ppm)	Nitrogen Dioxide (ppb)	Ozone (ppm)	PM10 (µg/m3)	PM2.5 (µg/m3)	Sulfur Dioxide (ppb)	Wind (knots)	Temperature (Fahrenheit)
Mean	0.31	8.60	0.03	19.66	8.53	1.69	4.50	56.53
Standard Deviation	0.27	7.63	**0.01**	**27.82**	7.29	4.74	**3.55**	**18.86**
Min	-0.50	-5.00	0.00	-53.00	-9.70	-4.00	0.00	-60.00
Max	44.90	179.41	0.14	16619.00	824.10	1068.83	1942.40	144.29

02. Annual Trends for Six Pollutants



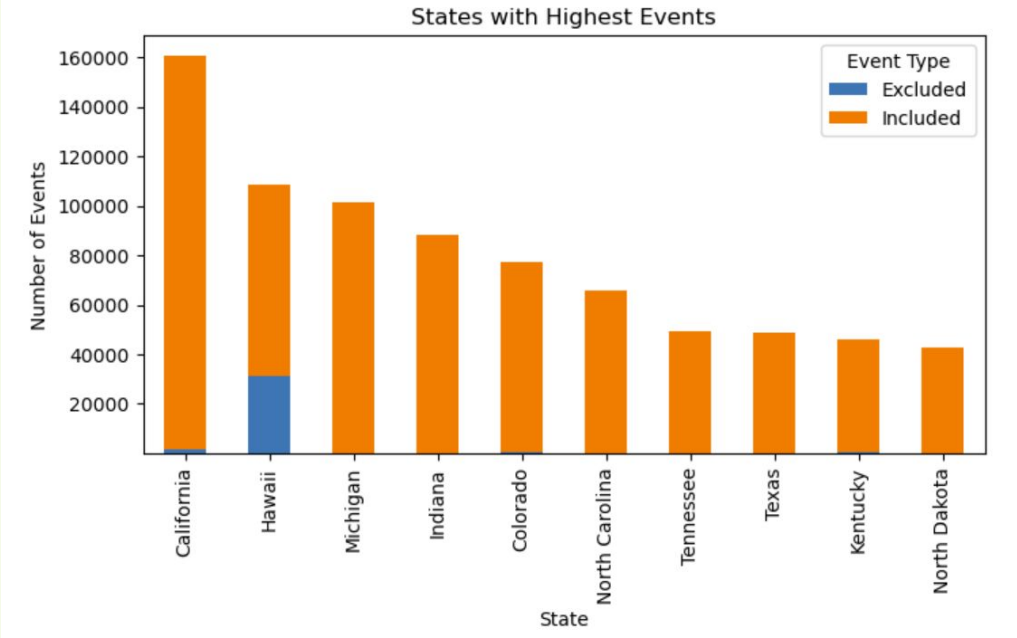




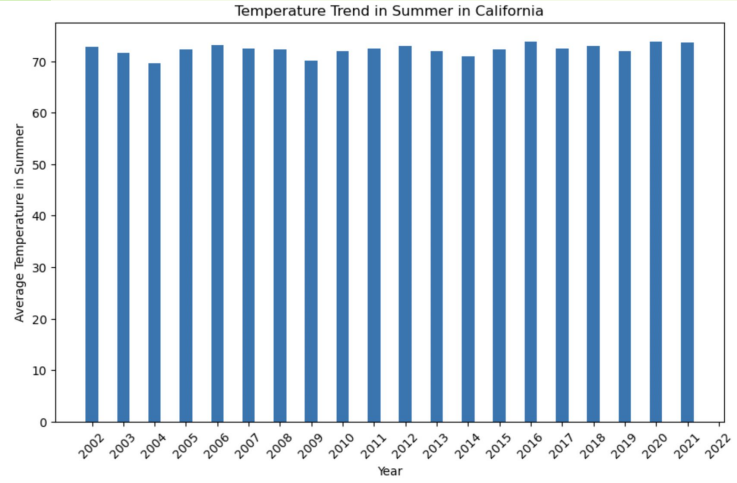
All measured pollutants, aside from Ozone, have decreased significantly across the country since the inception of the Clean Air Act of 1990.

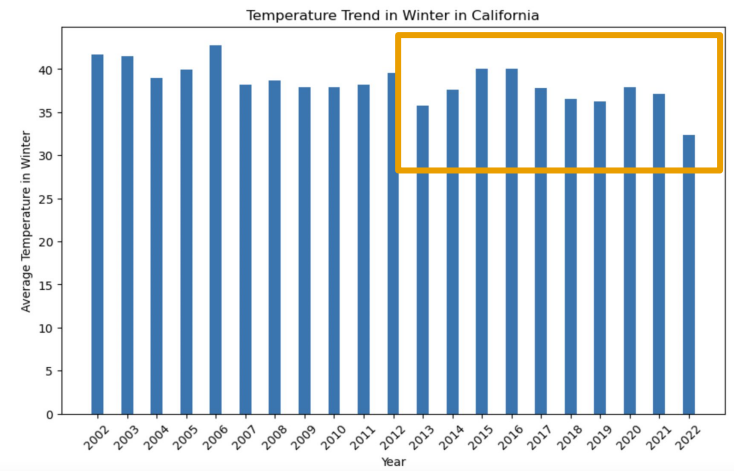
02. Event Analysis

- **Event Types**
  - Included events: EPA was able to measure
  - Excluded events: EPA did not capture
- **California has the highest number of events in total**
  - Climate: California has a Mediterranean climate
  - Geography: California is located on the Pacific Ring of Fire
  - Human activities: Unattended campfires, discarded cigarettes, and arson



03. Annual Temperature Trends in California





Summer

Winter

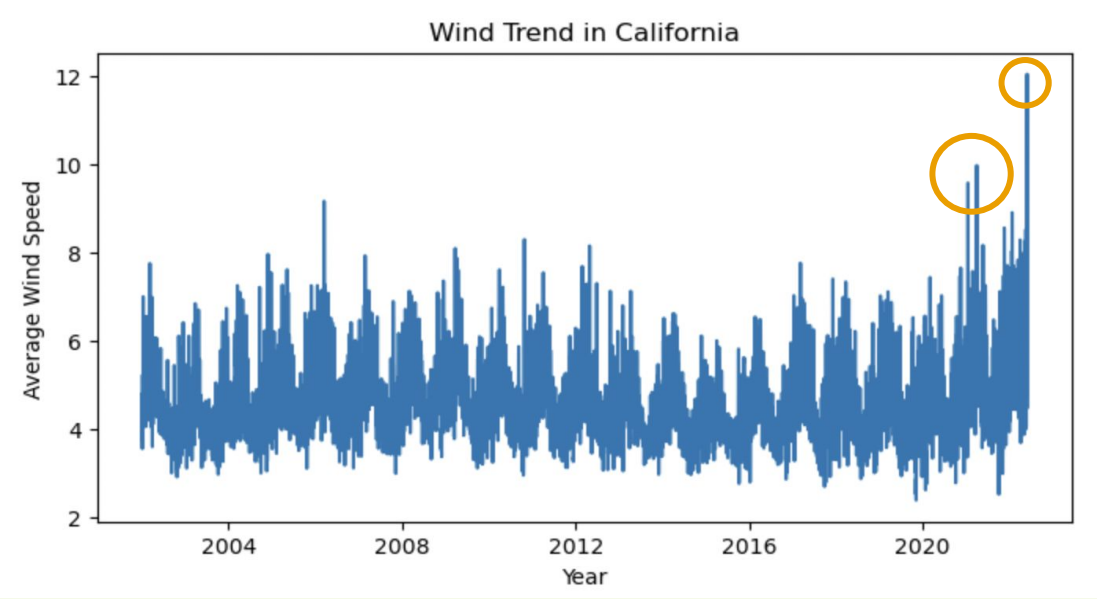
High Levels of Air Pollution

Cooling ⟷ Warming

reflecting sunlight

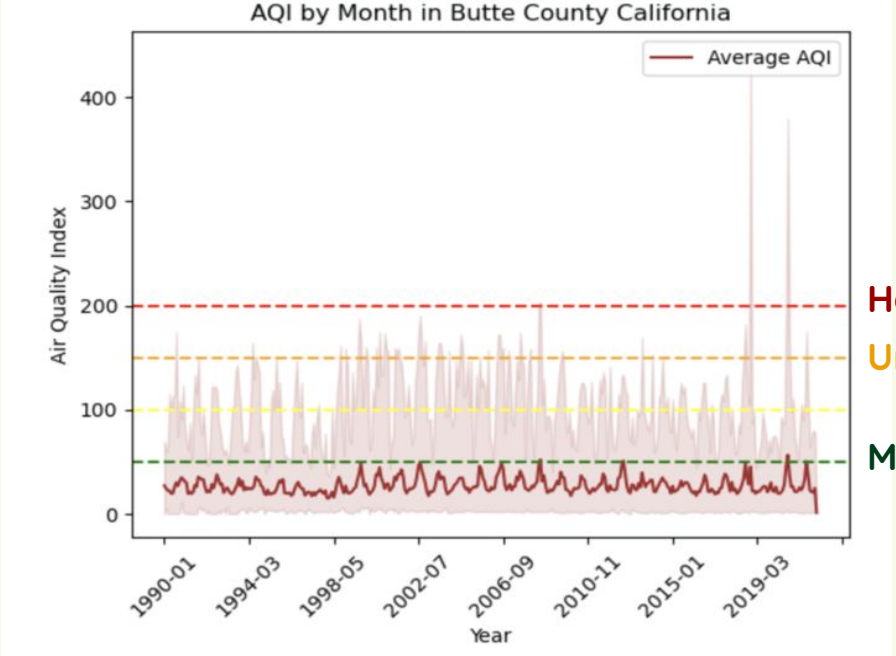
absorbing + trapping heat

03. Annual Wind Trend in California



- Wildfires:

03. AQI Trend in Butte



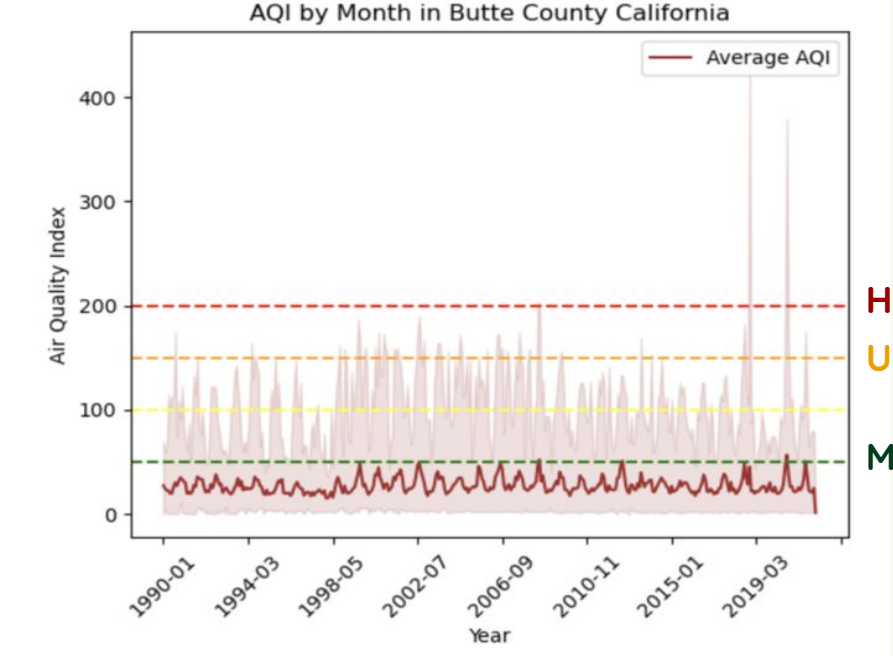
Hazardous

Unhealthy

Moderate

- Camp Fire (2018) burned 153,000+ acres
- North Complex Fire (2020) burned 318,000+ acres
- Dixie Fire (2021) burned 960,000+ acres

03. AQI Trend in Butte

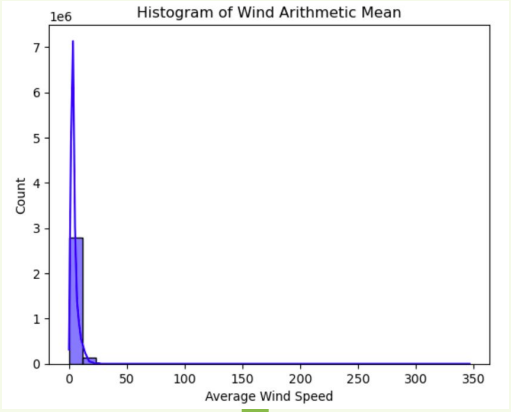


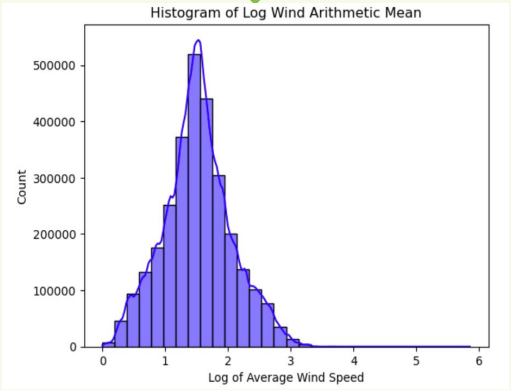
- Camp Fire (2018) burned 153,000+ acres (~1093 size of BU)
- North Complex Fire (2020) burned 318,000+ acres (~2272 size of BU)
- Dixie Fire (2021) burned 960,000+ acres (~6857 size of BU)

04. Prediction Model: Preparation

- **Data**
  - Features
    - Daily level concentrations for 6 pollutants (CO, NO_2, $PM_{2.5}$, PM_{10}, SO_2, O_3)
    - Wind and temperature
  - Label
    - Max AQI across all pollutants

- **Controlling for Skewness & Outliers**
  - Skewness: Wind log transform
  - Outliers: Interquartile Range (IQR) method





04. Prediction Model: Results

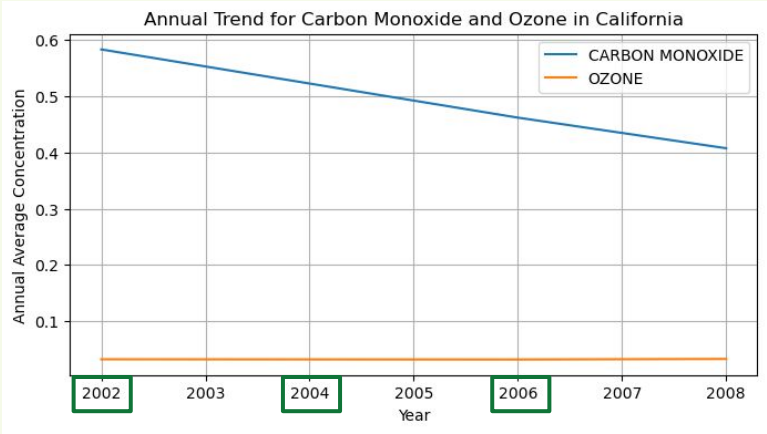
- Implemented **three Machine Learning Models** to predict AQI

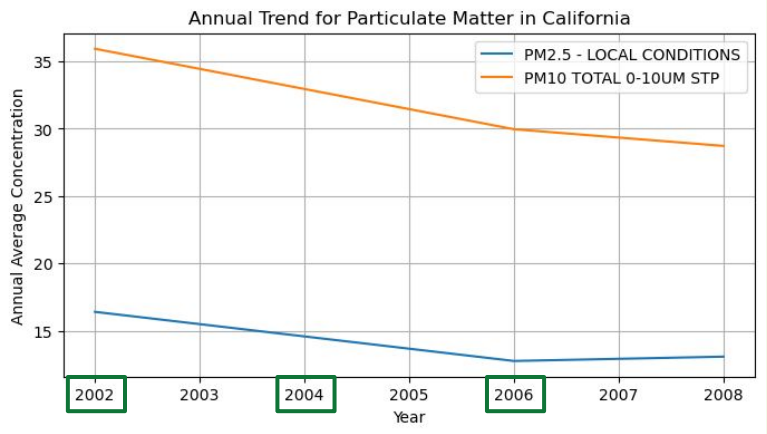
- **Gradient Boosted Tree** was the best performing model
  - On average 13 units off from the true AQI
  - AQI range (0,500) -> predictions are 2.6% off from the total range

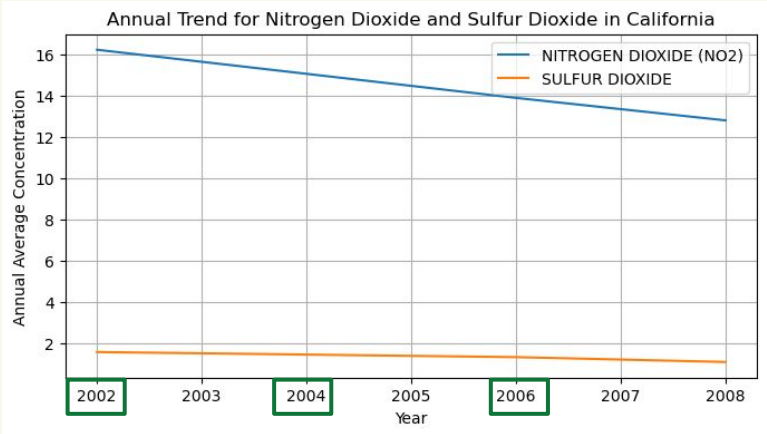
- **Grid Search** on GBT for max depth and learning rate (maxDepth=10, StepSize = 0.1)

	Linear Regression	Random Forest	Gradient Boosted Tree
Test RMSE	16.96	15.35	**13.60**
Test R^2	0.39	0.50	**0.60**

05. Legislation in California





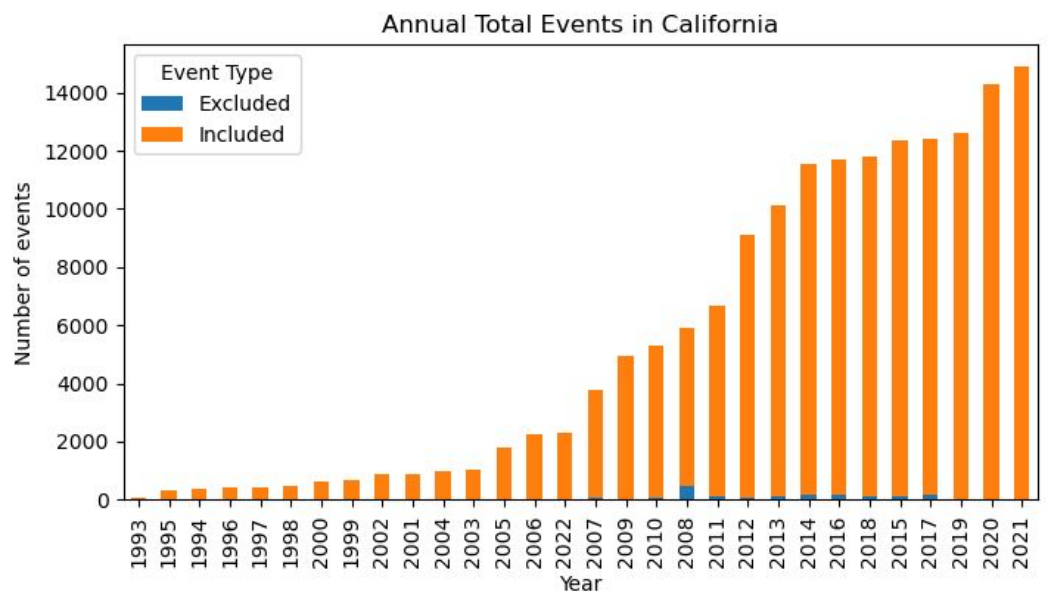


California Government proposed different legislation in 2002, 2004 and 2006 to protect the environment.

05. Annual Events in California

Human activities are a major driver of the environmental events contributed to the release of greenhouse gas emissions:

- Transportation
- Industry
- Land use
- Deforestation



05. Recommendations

- Increase the use of **renewable energy sources** such as solar, wind, and geothermal to reduce greenhouse gas emissions

- Improve building **energy efficiency standards** and promote the **use of energy-efficient appliances**, lighting, and heating and cooling systems

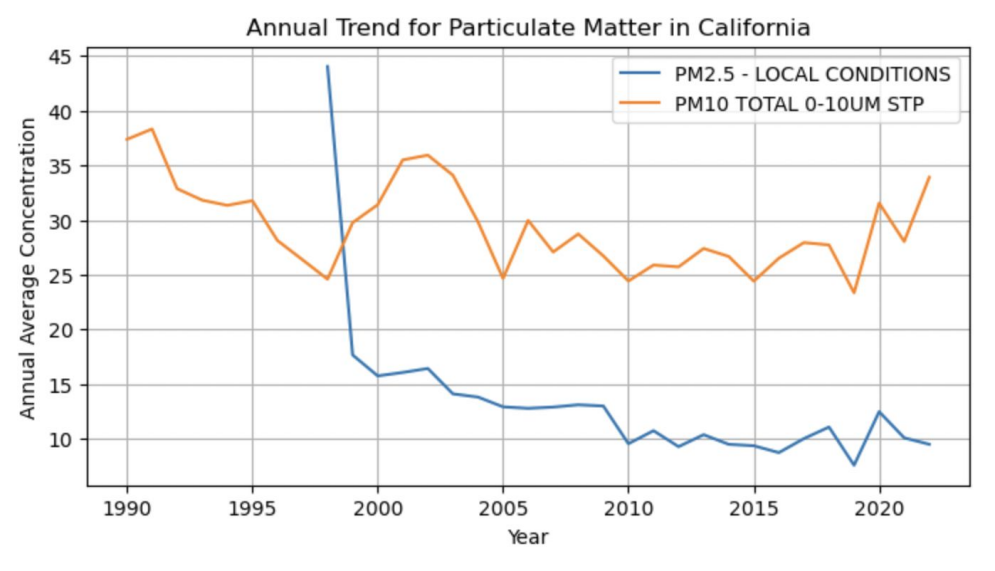
- Increase funding for **research and development of new technologies** that can reduce emissions such as carbon capture and storage, and hydrogen fuel cells

Thank You!
Any Questions?

References

1. AirNow (2023). Air Quality Index - A Guide to Air Quality and Your Health. AirNow. https://www.airnow.gov/aqi/aqi-basics/
2. California Air Resources Board (2023). California Ambient Air Quality Standards. State of California. https://ww2.arb.ca.gov/resources/california-ambient-air-quality-standards#:~:text=In%201959%20California%20enacted%20legislation,more%20stringent%20than%20national%20standards
3. California Department of Forestry and Fire Prevention (2023). Dixie Fire. State of California. https://www.fire.ca.gov/incidents/2021/7/13/dixie-fire/
4. OpenAI (2023). Chat with GPT-3.5. OpenAI. https://chat.openai.com/chat.
5. Pierre-Louis, K., Schwartz, J. (2021, July 16). Why Does California Have So Many Wildfires? The New York Times. https://www.nytimes.com/article/why-does-california-have-wildfires.html
6. Story, R. (2013). Python Visualization: Folium 0.14.0 Quickstart. Folium. https://python-visualization.github.io/folium/quickstart.html#Getting-Started
7. United States Environmental Protection Agency (2022). Historical Air Quality by the EPA. Google Cloud. https://console.cloud.google.com/marketplace/product/epa/historical-air-quality
8. United States Environmental Protection Agency (2018). Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index (AQI). AirNow. https://www.airnow.gov/sites/default/files/2020-05/aqi-technical-assistance-document-sept2018.pdf
9. United States Environmental Protection Agency (2015). File Formats. AQS Data Mart. https://aqs.epa.gov/aqsweb/airdata/FileFormats.html

Appendix I: Annual PM Trends in California



- **California Government Actions:**
  - Monitoring and reporting
  - Regulations on vehicle emissions
  - Air pollution controlling
  - Programs to reduce wildfire risk
- **Decreased 61%**

Appendix II: The Dixie Fire – Butte

The fire started on July 13, 2021,
and was fully contained on December 31, 2021.