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# **Air Quality and Climate Dynamics in California: Critical Facts for Insurance Focus Areas**

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# Meet the Project Team

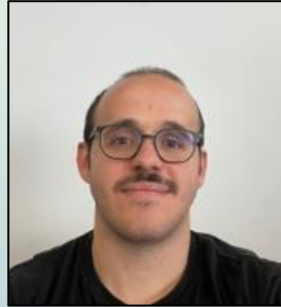
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Consultant



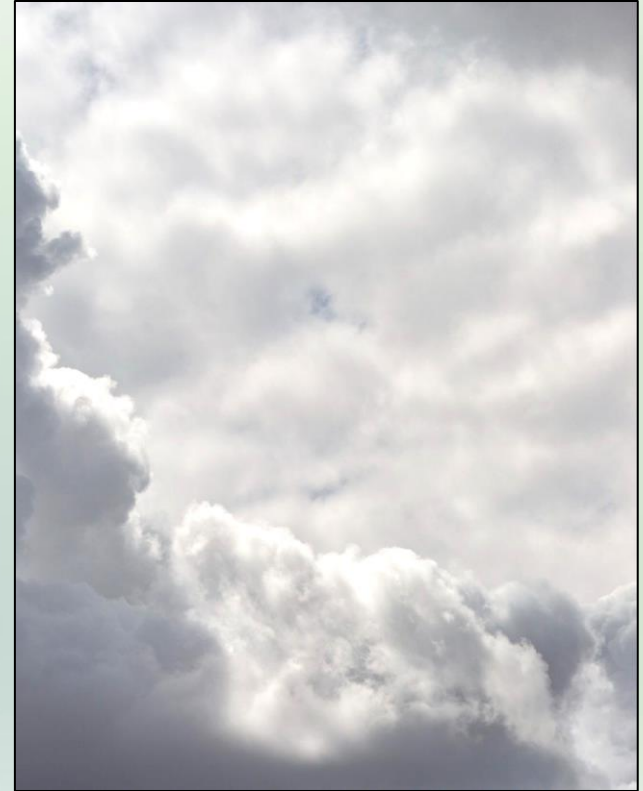
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- ☐ Integrated MSc in Food Science and Human Nutrition, A.U.A.
- ☐ Research and Data Analysis

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- ☐ MSc in Water Resources Science & Technology, NTUA



## **Mission:**

Examine the Dynamic Relationship Between Air Quality and Climate Patterns.  
Propose Insurance Solutions for California.

## **Importance:**

By identifying critical factual insights and focus areas in California we can enhance insurance risk assessment, pricing strategies, and policy management.

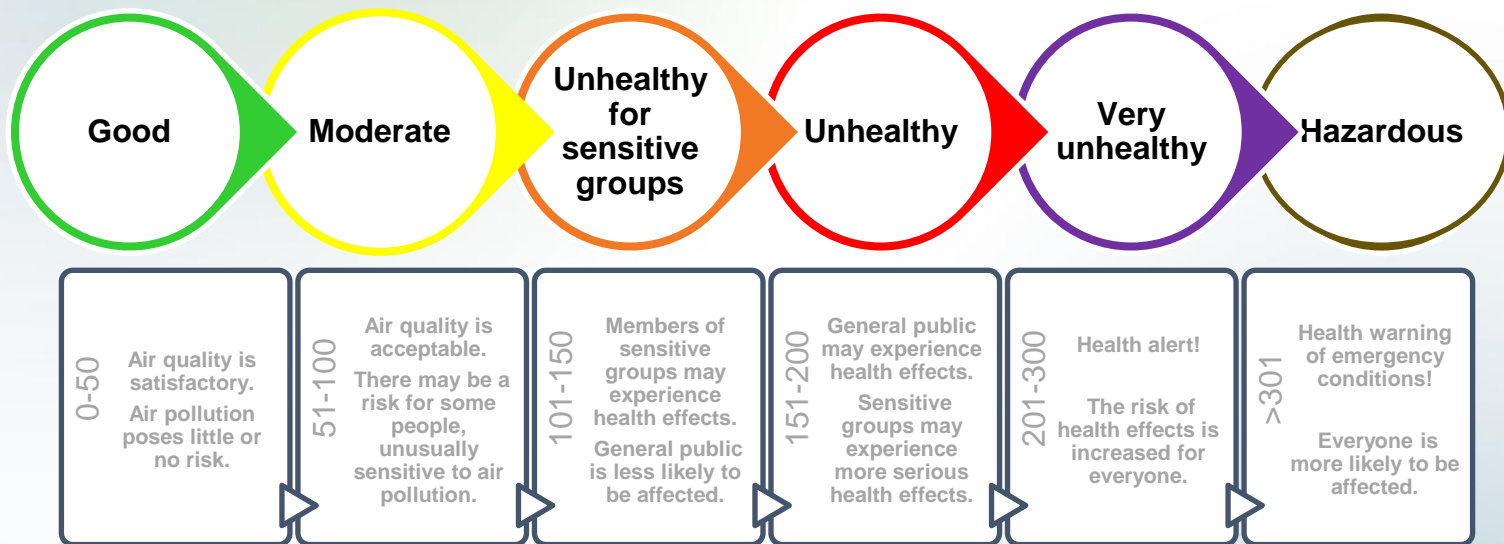


# Why California is an ideal case study for assessing air pollution risks?

- High levels of pollution
- Extensive network of monitoring stations
- Diverse geographic regions
- Strict environmental regulations



# Air Quality Index (AQI)



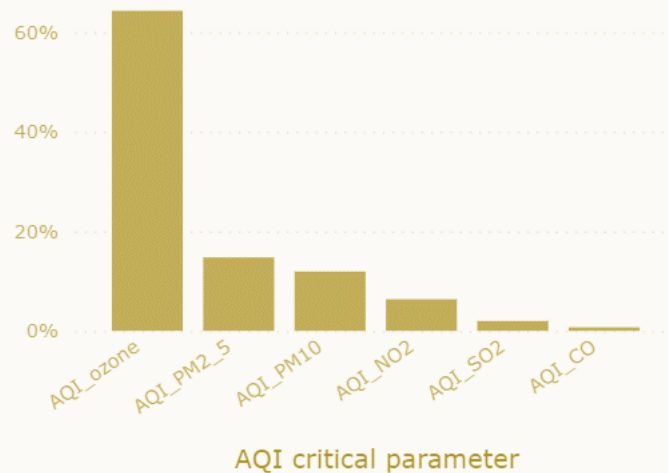
**GOAL:** safeguard public health

# Air Quality Index (AQI)

A standardized measure to **assess air quality** based on concentrations of major air pollutants.



Key pollutants contribution to AQI calculation



# Project Roadmap

## Data Collection

Collect Historical Data - Data Source: EPA  
20 years of weather, AQI and its key pollutants components daily data for all US states.

## Preliminary Analysis

Data Cleaning, Processing and EDA with Python (pandas, numpy) to identify States with the Highest Pollution Levels.

## Identify State of interest

Extensive monitoring, high pollution levels, geographic and climatic diversity, and regulatory environment.

## Searching for AQI correlations

Analyze the potential relationship between AQI and its key pollutants levels with weather data.

## Identify AQI and Heatwaves interplay

- Choose a county known for frequent heatwaves.
- Analyze the correlation between heatwaves, temperature spikes, and AQI.

## Monthly and Seasonal AQI Trends

Discuss patterns and trends observed in the data.

## Compare Urban and Rural AQI and its key pollutants

Analyze AQI data for urban and rural counties.

## Synthesize Findings

- Summarize key insights from the analysis.
- Highlight the most critical data points and correlations.

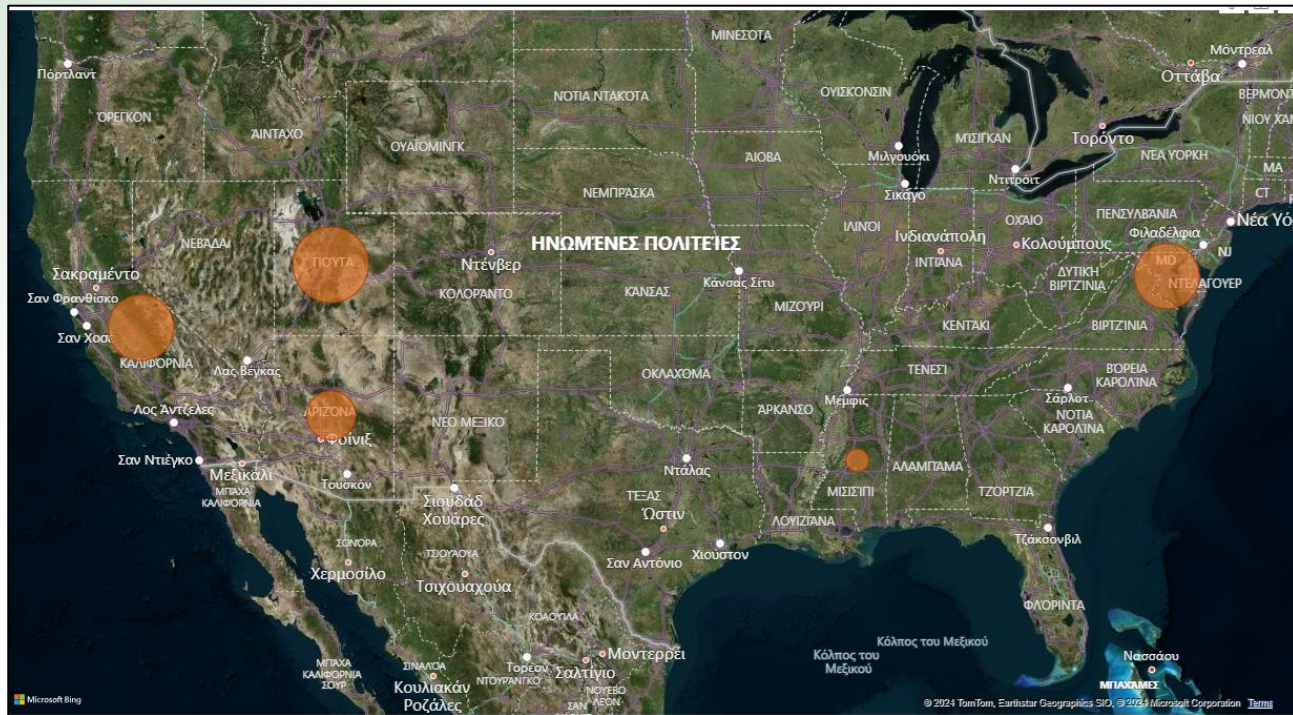
## Implications for Insurance

How to improve risk assessment, adjust policy pricing, anticipate claims, and develop new products.



# States with the worst air quality

20 years AQI average



AQI data: 12M records, 40 variables

Weather data: 6M records, 26 variables





# 90%

of Californians breathe unhealthy air during some part of the year.

PM2.5 pollution causes over 9K deaths in California annually, with a statistical range from 7K to 11K deaths.

*California Air Resources Board, 2010*

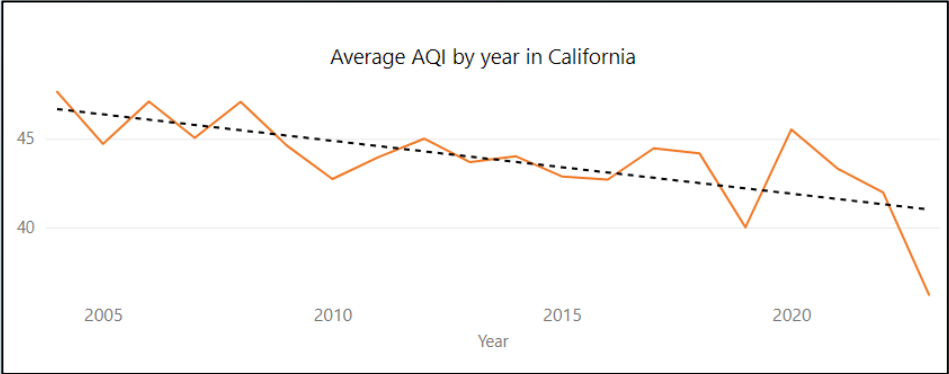
# California

## 3rd largest state by area

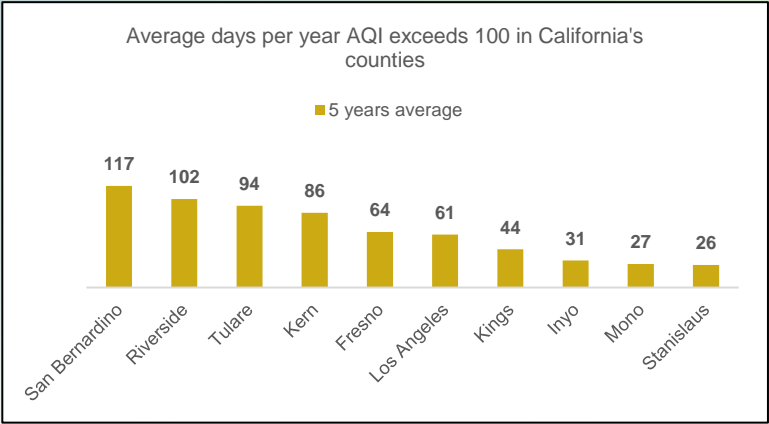
- 156K sq mi land area
- 8K sq mi water area
- 39M population
- 40 counties

source://data.census.gov/

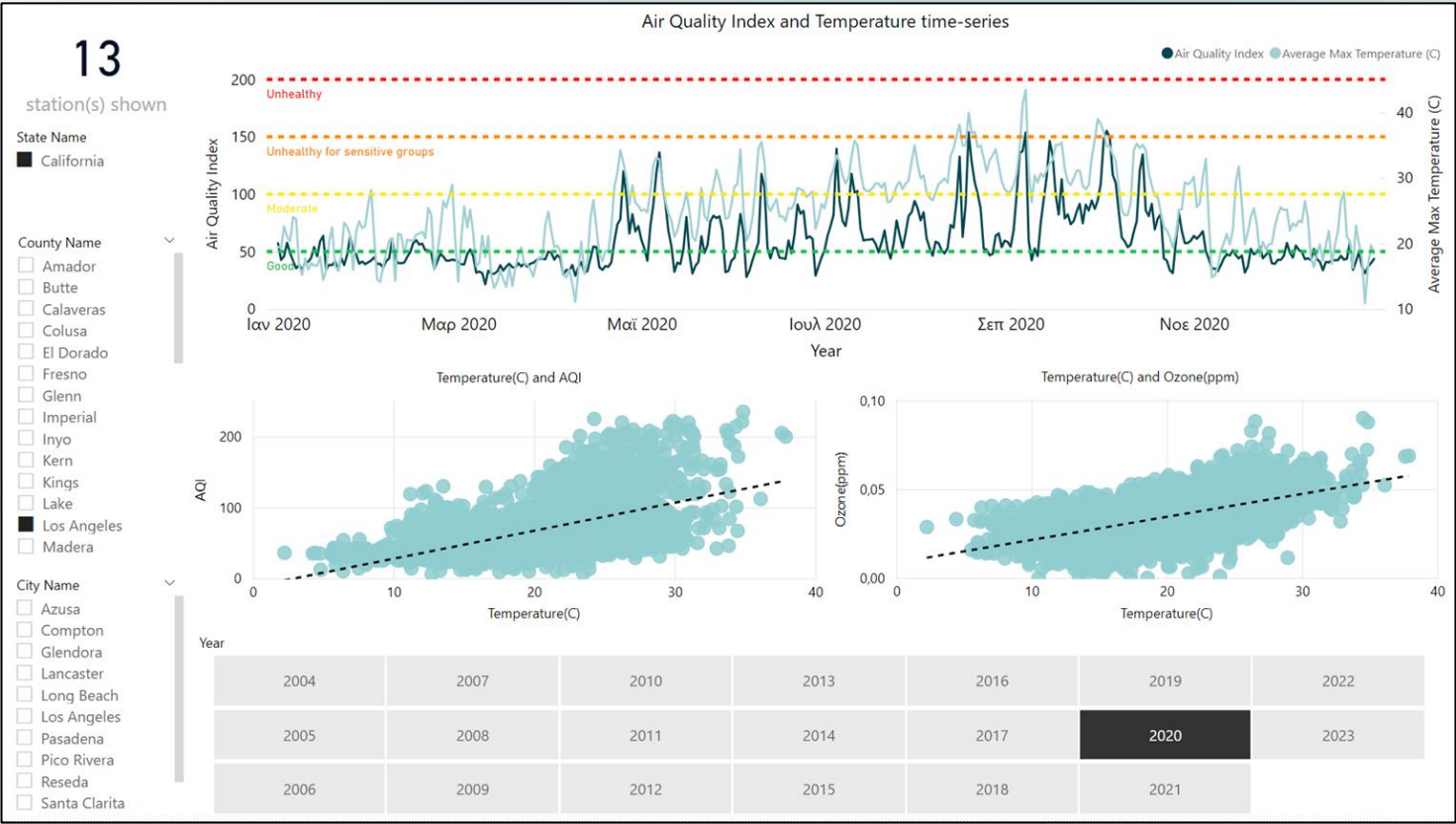
- 2004  
69 monitoring stations
- 2022  
84 monitoring stations



- Wildfires
- Vehicle Emissions
- Warm Climate and Ozone Formation
- Industrial Activities
- Geographical Factors



# AQI correlations-Temperature



# AQI and Heatwaves interplay in Los Angeles

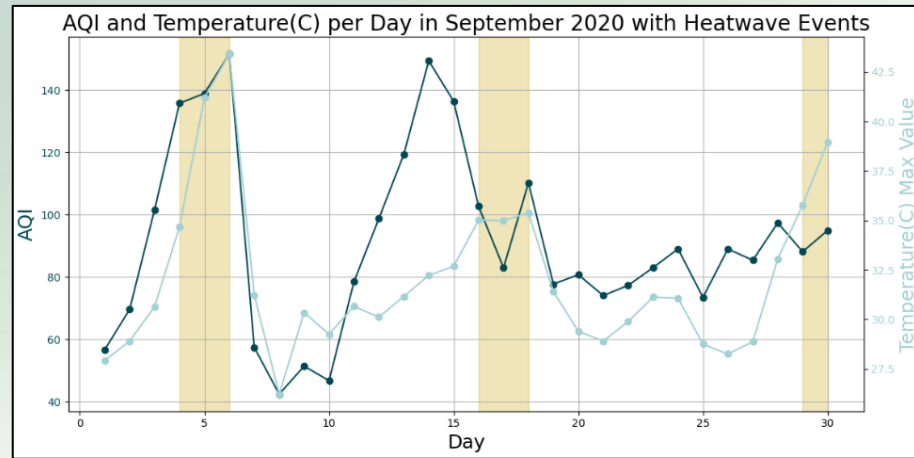
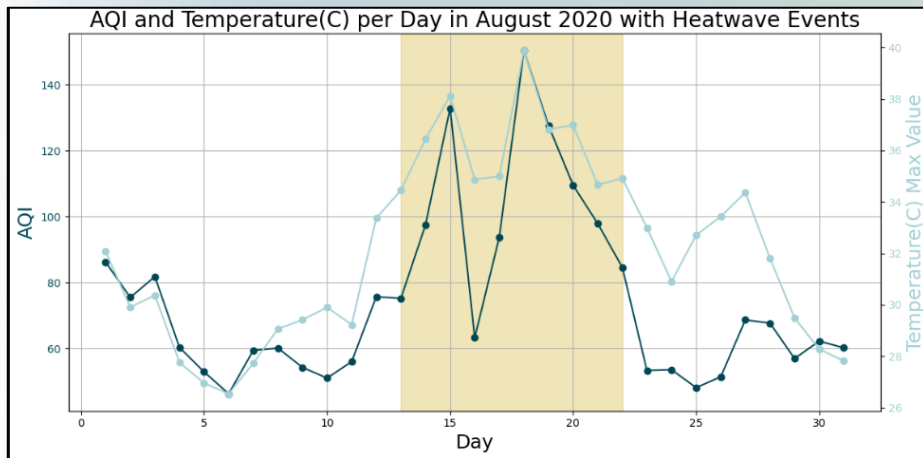
Stagnant Air Conditions

Inversions

**Heat Waves**

Wildfires

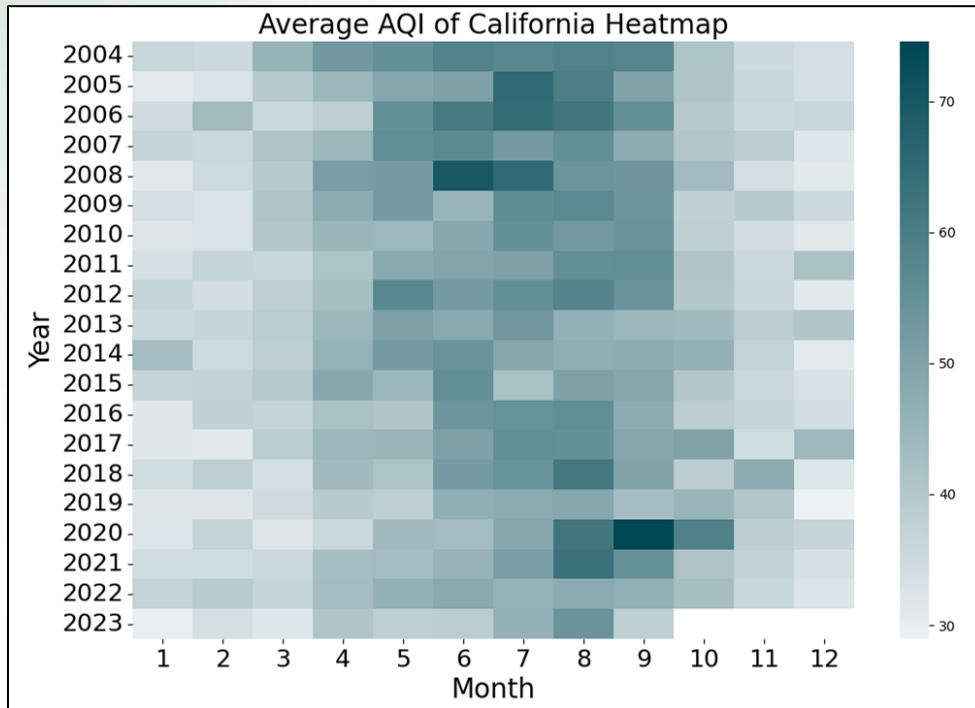
Formation of Ground-Level O<sub>3</sub> - Photochemical Reactions



# Monthly and seasonal AQI trends in California

## SUMMER

Consistent patterns highlighted in air quality across seasons.

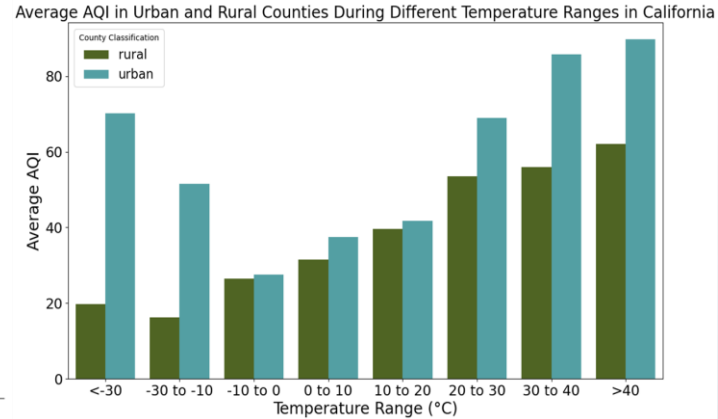
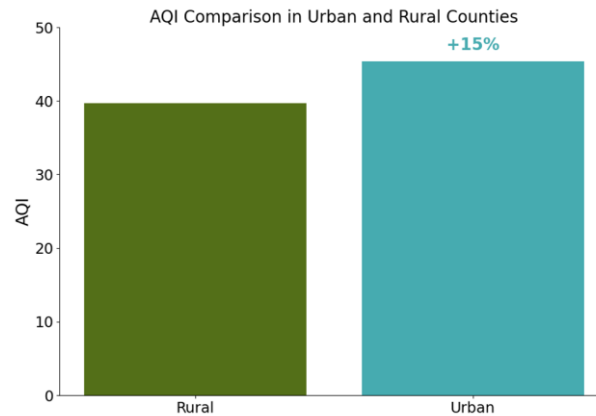
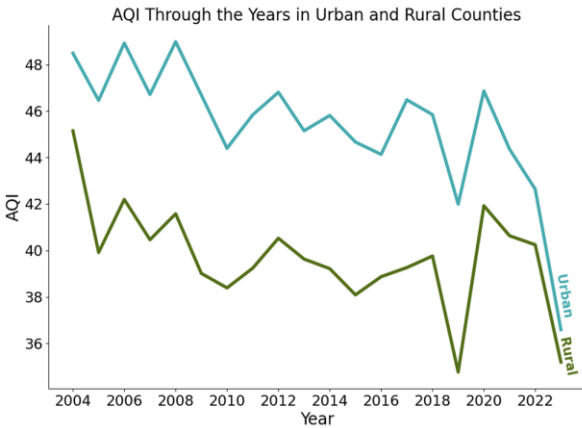


Outbreak of wildfires caused by a series of lightning strikes

August Complex California's largest recorded wildfire **gigafire**

The median AQI is higher, indicating generally poorer air quality. The spread of AQI values is also larger, suggesting more variability in AQI and some extreme high values.

# Urban and Rural AQI in California



Worse air quality in urban areas

Constant pattern throughout the years

Across all temperature ranges

Especially at very low and very high temperatures

# Urban and Rural key pollutants in California

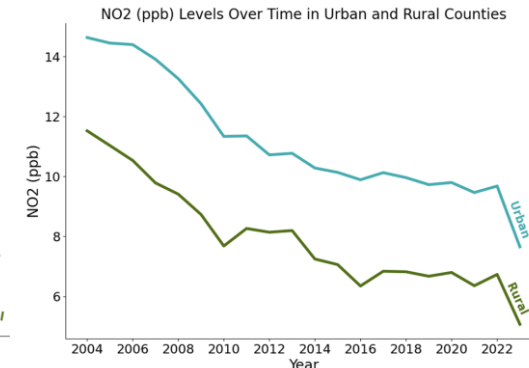
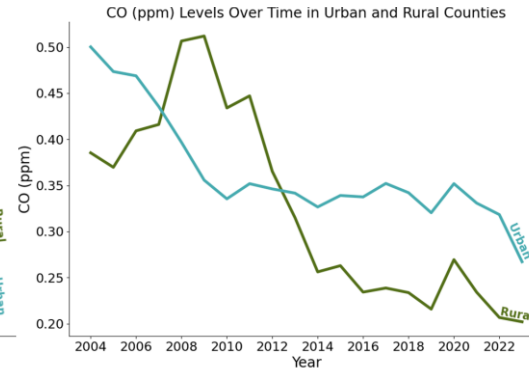
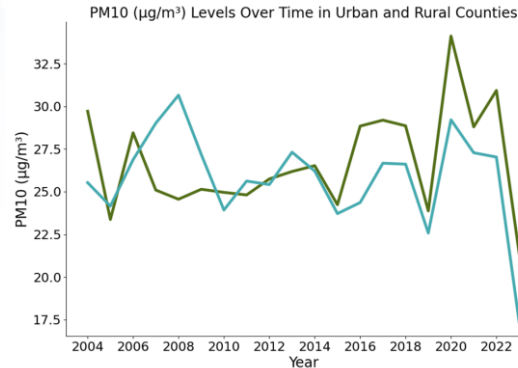
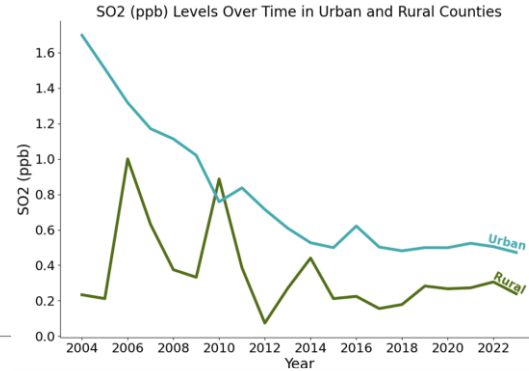
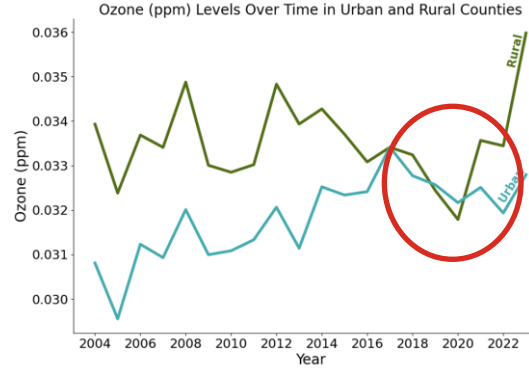
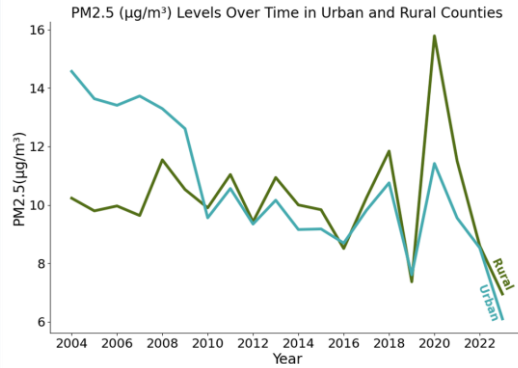
Urban

Rural

Concentration of PM10 and PM2.5 is stable over time.

Ozone is on the rise – rural areas seem more affected – COVID19 lockdowns had a positive effect.

The rest of pollutants had in general higher concentration in urban counties.





# Key Insights

## States to focus

1. Utah
2. California
3. Maryland
4. Arizona
5. Mississippi

## California's hotspots to focus

1. San Bernardino
2. Riverside
3. Tulare
4. Kern
5. Fresno
6. Los Angeles

## Temperature Effect

High Temperatures

Heatwaves

Wildfires

## Key Pollutants

O3  
PM2.5  
PM10

## Seasonal Variations

Summer months

Winter months - urban

## Urban vs. Rural

Urban

Rural-ozone

# Insurance Strategies for Air Quality Risks

## Adjust Premiums Based on Localized Air Quality Data

- **Action:** Focus on areas with historically poor air quality. Implement higher premiums in regions experiencing frequent heatwaves and elevated ozone levels due to increased health risks and potential claims.


## Develop Specialized Health Coverage

- **Action:** Health insurance products that cover respiratory and cardiovascular conditions exacerbated by air pollution. There is a growing demand for specialized health coverage in affected areas.

## Predictive Analytics to Anticipate Claims

- **Action:** Predictive analytics to forecast and prepare for spikes in claims during high risk periods. Use historical data from California's most affected regions. Acting proactively can mitigate financial impact and improve customer service during high-risk periods.

# Further Research



Data Integration

Spatial Analysis

Product Development

Technology  
Investment

# References:

- U.S. Environmental Protection Agency. (2024). Air quality data. Retrieved from <https://www.epa.gov/outdoor-air-quality-data>
- California Air Resources Board. (2024). Health and air pollution. Retrieved from <https://ww2.arb.ca.gov/resources/health-air-pollution>
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- Alan Buis, NASA's Jet Propulsion Laboratory (9/2015). Retrieved from <https://climate.nasa.gov/news/2346/background-ozone-a-major-issue-in-us-west/>

# THANK YOU!

## DO YOU HAVE ANY QUESTIONS?

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**Angeliki Lagogianni**

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**Stelios Vasilakis**

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**When did you become an expert  
in air pollution and meteorology?**



**Last night**

# Appendix

## Key Pollutants health effects

<u>Pollutant</u>	<u>Effects on Health and the Environment</u>
<u>Ozone (O<sub>3</sub>)</u>	<ul style="list-style-type: none"><li>• Respiratory symptoms</li><li>• Worsening of lung disease leading to premature death</li><li>• Damage to lung tissue</li><li>• Crop, forest and ecosystem damage</li><li>• Damage to a variety of materials, including rubber, plastics, fabrics, paint and metals</li></ul>
<u>PM<sub>2.5</sub></u> <u>(particulate matter less than 2.5 microns in aerodynamic diameter)</u>	<ul style="list-style-type: none"><li>• Premature death</li><li>• Hospitalization for worsening of cardiovascular disease</li><li>• Hospitalization for respiratory disease</li><li>• Asthma-related emergency room visits</li><li>• Increased symptoms, increased inhaler usage</li></ul>
<u>PM<sub>10</sub></u> <u>(particulate matter less than 10 microns in aerodynamic diameter)</u>	<ul style="list-style-type: none"><li>• Premature death &amp; hospitalization, primarily for worsening of respiratory disease</li><li>• Reduced visibility and material soiling</li></ul>
<u>Nitrogen Oxides (NO<sub>x</sub>)</u>	<ul style="list-style-type: none"><li>• Lung irritation</li><li>• Enhanced allergic responses</li></ul>
<u>Carbon Monoxide (CO)</u>	<ul style="list-style-type: none"><li>• Chest pain in patients with heart disease</li><li>• Headache</li><li>• Light-headedness</li><li>• Reduced mental alertness</li></ul>
<u>Sulfur Oxides (SO<sub>x</sub>)</u>	<ul style="list-style-type: none"><li>• Worsening of asthma: increased symptoms, increased medication usage, and emergency room visits</li></ul>
<u>Lead</u>	<ul style="list-style-type: none"><li>• Impaired mental functioning in children</li><li>• Learning disabilities in children</li><li>• Brain and kidney damage</li></ul>
<u>Hydrogen Sulfide (H<sub>2</sub>S)</u>	<ul style="list-style-type: none"><li>• Nuisance odor (rotten egg smell)</li><li>• At high concentrations: headache &amp; breathing difficulties</li></ul>
<u>Sulfate</u>	<ul style="list-style-type: none"><li>• Same as PM<sub>2.5</sub>, particularly worsening of asthma and other lung diseases</li><li>• Reduces visibility</li></ul>
<u>Vinyl Chloride</u>	<ul style="list-style-type: none"><li>• Central nervous system effects, such as dizziness, drowsiness &amp; headaches</li><li>• Long-term exposure: liver damage &amp; liver cancer</li></ul>
<u>Visibility Reducing Particles</u>	<ul style="list-style-type: none"><li>• Reduced airport safety, scenic enjoyment, road safety, and discourages tourism</li></ul>
<u>Toxic Air Contaminants</u> <u>About 200 chemicals have been listed as toxic air contaminants</u>	<ul style="list-style-type: none"><li>• Cancer</li><li>• Reproductive and developmental effects</li><li>• Neurological effects</li></ul>



# Calculating AQI Example

## 1. Monitoring Pollutant Concentrations:

- **Ozone ( $O_3$ )**: Measured concentration is 70 parts per billion (ppb).
- **Particulate Matter PM<sub>2.5</sub>**: Measured concentration is 25 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ).

## 2. Calculating AQI Sub-Indices:

### For Ozone ( $O_3$ ):

- Ozone concentration: 70 ppb.
- AQI breakpoints for ozone (using the EPA standards):
  - 0-54 ppb: Good (AQI 0-50)
  - 55-70 ppb: Moderate (AQI 51-100)

Since 70 ppb falls into the Moderate category:

$$AQIO_3=100$$

### For Particulate Matter PM<sub>2.5</sub>:

- PM<sub>2.5</sub> concentration: 25  $\mu\text{g}/\text{m}^3$ .
- AQI breakpoints for PM<sub>2.5</sub> (using the EPA standards):
  - 0-12.0  $\mu\text{g}/\text{m}^3$ : Good (AQI 0-50)
  - 12.1-35.4  $\mu\text{g}/\text{m}^3$ : Moderate (AQI 51-100)

Since 25  $\mu\text{g}/\text{m}^3$  falls into the Moderate category:

$$AQIPM_{2.5}=66$$

## 3. Determining the Overall AQI:

- Compare the AQI values calculated for ozone and PM<sub>2.5</sub>.
- In this example:
  - $AQIO_3=100$
  - $AQIPM_{2.5}=66$

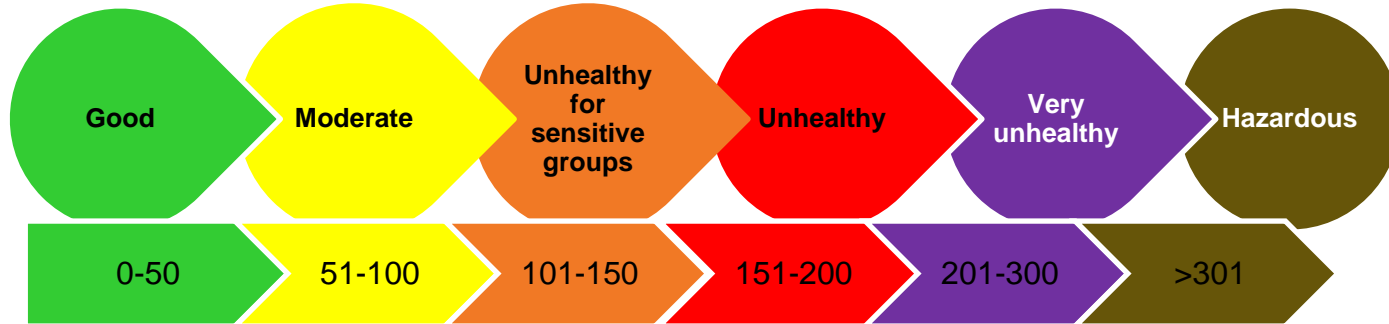
The overall AQI is determined by the highest sub-index value among all pollutants:

$$\text{Overall AQI}=\max(AQIO_3, AQIPM_{2.5})=\max(100, 66)=100$$

## 4. Interpreting the AQI:

- An overall AQI of 100 indicates Moderate air quality.
- Health advisories might recommend that sensitive individuals limit prolonged outdoor exertion, particularly during periods of high ozone and particulate matter concentrations..

# Air Quality Index



**0-50**  
Air quality is satisfactory.  
Air pollution poses little or no risk.

**51-100**  
Air quality is acceptable.  
There may be a risk for some people, unusually sensitive to air pollution.

**101-150**  
Members of sensitive groups may experience health effects.  
General public is less likely to be affected.

**151-200**  
General public may experience health effects.  
Sensitive groups may experience more serious health effects.

**201-300**  
Health alert!  
The risk of health effects is increased for everyone.

**>301**  
Health warning of emergency conditions!  
Everyone is more likely to be affected.