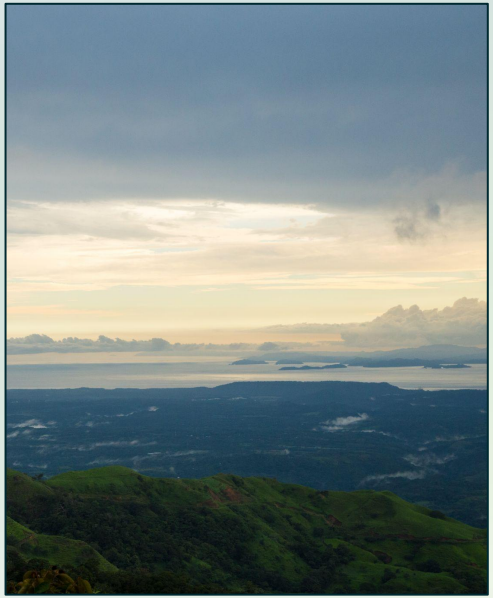
Environmental ML Analytics:
NC Urban Areas

Ariana, Natalie, Mary, Jolyciel

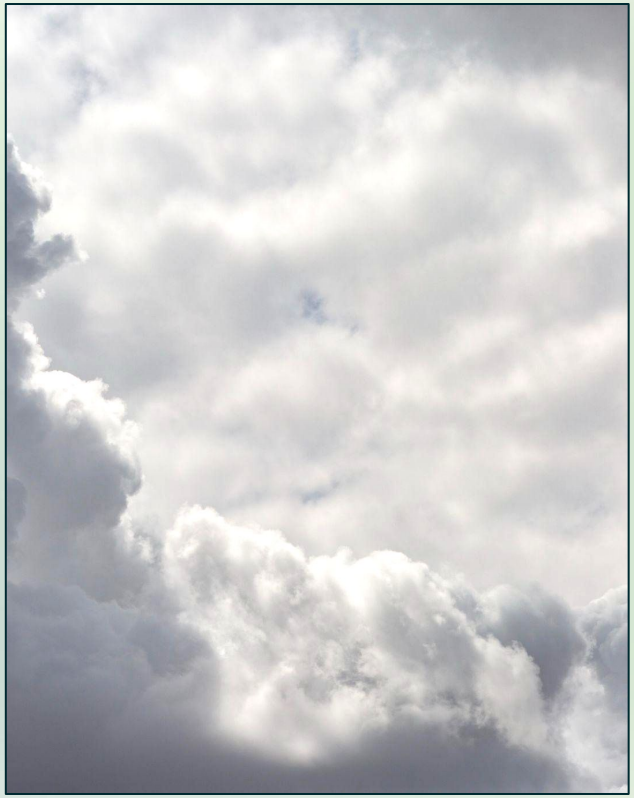
TABLE OF CONTENTS



WHY AIR?

Want to predict Air Quality in North Carolina.

- Asthma
- Allergies
- Respiratory health
- Environmental Health



Our Goal:

Predict the number of unhealthy days in the 2023 year, using data that goes as far back as 1980.

Our Focus:

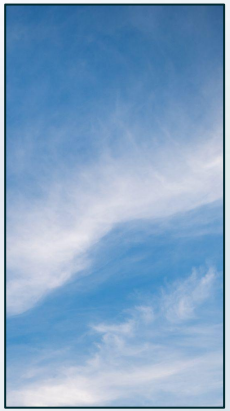
Primarily focus on Mecklenburg County and Wake County, home to the largest city and capital of North Carolina.

What is AQI?

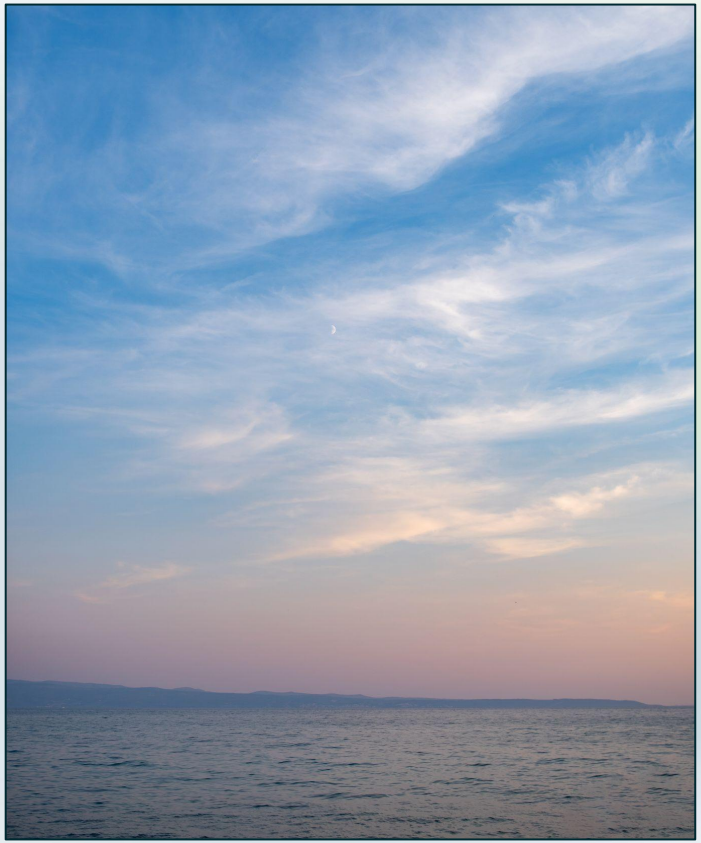
AQI is a numerical scale that communicates the quality of the air.

- Calculated based on the concentrations of specific air pollutants
- AQI scale is divided into different categories
- Categories often include ranges such as "Good," "Moderate," "Unhealthy for Sensitive Groups," "Unhealthy," etc

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon



1



Data Clean Up

Data Sets

- Obtained CSV files for US counties (1980-2022)
- Merged files
- Selected NC counties
- Dropped null/duplicates
- Created single merged file

Source: *United States Environmental Protection Agency*
https://aqs.epa.gov/aqsweb/airdata/download_files.html#Annual

State	County	Year	Days with AQI	Good Days	Moderate Days	Unhealthy for Sensitive Groups Days	Unhealthy Days	Very Unhealthy Days	Hazardous Days	Max AQI	90th Percentile AQI	Median AQI	Days CO	Days NO2	Days Ozone	Days PM2.5	Days PM10
North Carolina	Alamance	2000	104	37	66	1	0	0	0	104	76	56	0	0	0	104	0
North Carolina	Alexander	2000	211	94	64	48	5	0	0	182	126	58	0	0	211	0	0
North Carolina	Avery	2000	365	211	117	34	3	0	0	172	101	47	0	0	353	12	0
North Carolina	Buncombe	2000	260	129	110	15	6	0	0	179	93	51	0	0	176	84	0
North Carolina	Cabarrus	2000	115	36	78	1	0	0	0	118	86	56	0	0	0	114	1

Gather 2023 Data

1. Gather individual csv files for each pollutant
   - Contain Daily records & AQI value for pollutant
2. Merge all csv files
3. Create DataFrames
   - Focus on 2 counties with ALL available data
4. Sort By Date & Gather Required Data

	DATE	COUNTY	CO_DAILY_AQI_VALUE	NO2_DAILY_AQI_VALUE	OZONE_DAILY_AQI_VALUE	PM2_DAILY_AQI_VALUE	PM10_DAILY_AQI_VALUE
0	2023-01-01	Wake	5.0	NaN	NaN	NaN	NaN
544	2023-01-01	Wake	NaN	16.0	NaN	NaN	NaN
1082	2023-01-01	Wake	NaN	NaN	23.0	NaN	NaN
1459	2023-01-01	Wake	NaN	NaN	NaN	35.0	NaN
273	2023-01-01	Wake	5.0	NaN	NaN	NaN	NaN

Breakdown of Required Data

Days of { *Pollutant* }
- Total count of { *Pollutant* } with the max AQI for the day

90th Percentile AQI
- From all max Daily AQI Values

Year	County	90th Percentile AQI	Days CO	Days NO2	Days OZONE	Days PM2.5	Days PM10
2023	Mecklenburg	71.0	0	1	218	108	0
2023	Wake	63.0	0	2	175	148	0

Columns Required for Model:

- 90th Percentile AQI
- Days CO
- Days NO2
- Days OZONE
- Days PM2.5
- Days PM10

Breakdown of Required Data

To Gather Data:

- Change null values to zero
- Group by Date, keep maximums
- Create new columns for required data
- Use for loop to find:
  - Max AQI values for each pollutant
  - Pollutant with Max AQI value
    - Keep count of pollutants
  - Overall Max AQI for the date
- Find 90th Percentile of all Daily Max AQI Values
- Find Sum of count of pollutants
- New Data Frame with required columns
- Export to CSV to Use in Model

Resources

⟶ ***nc_2023_data.csv***

2

Database Sets

Data Retrieval

1. Loading the Data

```
# load the data from your CSV file into a pandas DataFrame.
import pandas as pd

# Load the data
file_path = '/Users/nataliiabondarenko/Desktop/GitHub/project-4/Resources/nc_aqi_1980-2022.csv'
data = pd.read_csv(file_path)

# Preview the data
print(data.head())
```

```
[1]
...
      County  Year  Days with AQI  Good Days  Moderate Days  \
0  Buncombe  2000          260.0      129.0          110.0
1  Buncombe  2001          253.0      141.0          100.0
2  Buncombe  2002          260.0      144.0           83.0
3  Buncombe  2003          303.0      178.0          110.0
4  Buncombe  2004          357.0      187.0          166.0

   Unhealthy for Sensitive Groups Days  Unhealthy Days  Very Unhealthy Days  \
0                                 15.0             6.0                  0.0
1                                 11.0             1.0                  0.0
2                                 27.0             6.0                  0.0
3                                  6.0             0.0                  0.0
4                                  4.0             0.0                  0.0

   Hazardous Days  Max AQI  90th Percentile AQI  Median AQI  Days CO  \
0             0.0    179.0                 93.0        51.0      0.0
1             0.0    171.0                 87.0        48.0      0.0
2             0.0    179.0                108.0        48.0      0.0
3             0.0    137.0                 72.0        46.0      0.0
4             0.0    133.0                 74.0        49.0      0.0

   Days NO2  Days Ozone  Days PM2.5  Days PM10
0       0.0       176.0        84.0        0.0
1       0.0       174.0        78.0        1.0
2       0.0       172.0        88.0        0.0
```

```
# Checking for missing values
print(data.isnull().sum())
```

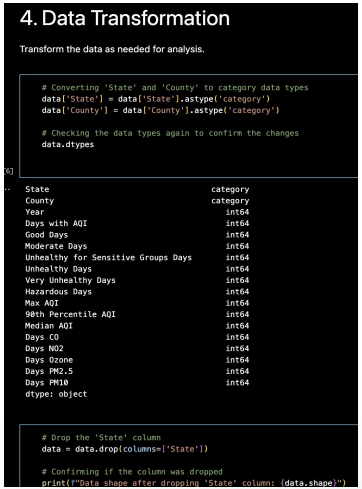
```
[4]
...
County                                0
Year                                  0
Days with AQI                         0
Good Days                             0
Moderate Days                         0
Unhealthy for Sensitive Groups Days   0
Unhealthy Days                        0
Very Unhealthy Days                   0
Hazardous Days                        0
Max AQI                               0
90th Percentile AQI                   0
Median AQI                            0
Days CO                               0
Days NO2                              0
Days Ozone                            0
Days PM2.5                            0
Days PM10                             0
dtype: int64
```

3. Data Cleaning

Based on the inspection, perform necessary cleaning steps

```
# Removing duplicates
data = data.drop_duplicates()

# Confirming if any duplicates were removed
print(f"Data shape after removing duplicates: {data.shape}")
```



4. Data Transformation

Transform the data as needed for analysis.

```
# Converting 'State' and 'County' to category data types
data['State'] = data['State'].astype('category')
data['County'] = data['County'].astype('category')

# Checking the data types again to confirm the changes
data.dtypes
```

```
[6]
...
State                                category
County                               category
Year                                    int64
Days with AQI                           int64
Good Days                               int64
Moderate Days                           int64
Unhealthy for Sensitive Groups Days     int64
Unhealthy Days                          int64
Very Unhealthy Days                     int64
Hazardous Days                          int64
Max AQI                                 int64
90th Percentile AQI                     int64
Median AQI                              int64
Days CO                                 int64
Days NO2                                int64
Days Ozone                              int64
Days PM2.5                              int64
Days PM10                               int64
dtype: object
```

```
# Drop the 'State' column
data = data.drop(columns=['State'])

# Confirming if the column was dropped
print(f"Data shape after dropping 'State' column: {data.shape}")
```

Process:

- Data cleaning and data inspection
- Data transformation
- Data export
- DB storage

(Python Pandas)

SQLite

```
SQLite format 3

A%
AÉa))Ü}tablepredicted_2023predicted_2023CREATE TABLE predicted_2023 (
        "County" TEXT,
        "Year" BIGINT,
        "Days with AQI" FLOAT,
        "Good Days" FLOAT,
        "Moderate Days" FLOAT,
        "Unhealthy for Sensitive Groups Days" FLOAT,
        "Unhealthy Days" FLOAT,
        "Very Unhealthy Days" FLOAT,
        "Hazardous Days" FLOAT,
        "Max AQI" FLOAT,
        "90th Percentile AQI" FLOAT,
        "Median AQI" FLOAT,
        "Days CO" FLOAT,
        "Days NO2" FLOAT,
        "Days Ozone" FLOAT,
        "Days PM2.5" FLOAT,
        "Days PM10" FLOAT
)ÉX##Üwtableair_qualityair_qualityCREATE TABLE air_quality (
        "County" TEXT,
        "Year" BIGINT,
        "Days with AQI" FLOAT,
        "Good Days" FLOAT,
        "Moderate Days" FLOAT,
        "Unhealthy for Sensitive Groups Days" FLOAT,
        "Unhealthy Days" FLOAT,
        "Very Unhealthy Days" FLOAT,
        "Hazardous Days" FLOAT,
        "Max AQI" FLOAT,
        "90th Percentile AQI" FLOAT,
        "Median AQI" FLOAT,
        "Days CO" FLOAT,
        "Days NO2" FLOAT,
        "Days Ozone" FLOAT,
        "Days PM2.5" FLOAT,
        "Days PM10" FLOAT
```

5. Data Export

After cleaning export it to a new CSV file or directly use it for further analysis or machine learning.

```
[8]  # Exporting to a new CSV file
     cleaned_file_path = '/Users/nataliiabondarenko/Desktop/GitHub/project-4/Resources/cleaned_data.csv'
     data.to_csv(cleaned_file_path, index=False)
```

6. Database Storage

```
[8]  from sqlalchemy import create_engine

     # Create an engine that stores data in the local directory's file
     engine = create_engine('sqlite:///nc_aqi_data1.db')
```

```
[9]  # Store the data in a table named 'air_quality'
     data.to_sql('air_quality', con=engine, if_exists='replace', index=False)

     # Store the data in a table named 'predicted_2023'
     data.to_sql('predicted_2023', con=engine, if_exists='replace', index=False)
...  1596
```

(SQL Database)

Data Preprocessing

Feature engineering is a step in the data preprocessing phase which is an essential part of preparing data for machine learning models

```
# Adding new features based on the existing data

# Ratio of Good to Moderate Days
data['Good_to_Moderate_Ratio'] = data['Good Days'] / data['Moderate Days']

# Percentage of Unhealthy Days (of all types)
data['Unhealthy_Days_Percentage'] = (
    data['Unhealthy for Sensitive Groups Days'] + data['Unhealthy Days'] + data['Very Unhealthy Days'] + data['Hazardous Days']
) / data['Days with AQI'] * 100

# Display the first few rows with the new features
data[['County', 'Year', 'Good_to_Moderate_Ratio', 'Unhealthy_Days_Percentage']].head()
```

	County	Year	Good_to_Moderate_Ratio	Unhealthy_Days_Percentage
0	Buncombe	2000	1.172727	8.076923
1	Buncombe	2001	1.410000	4.743083
2	Buncombe	2002	1.734940	12.692308
3	Buncombe	2003	1.495798	1.980198
4	Buncombe	2004	1.126506	1.120448

Data Saving

Saved as cleaned_data.csv and nc_aqi_data.db

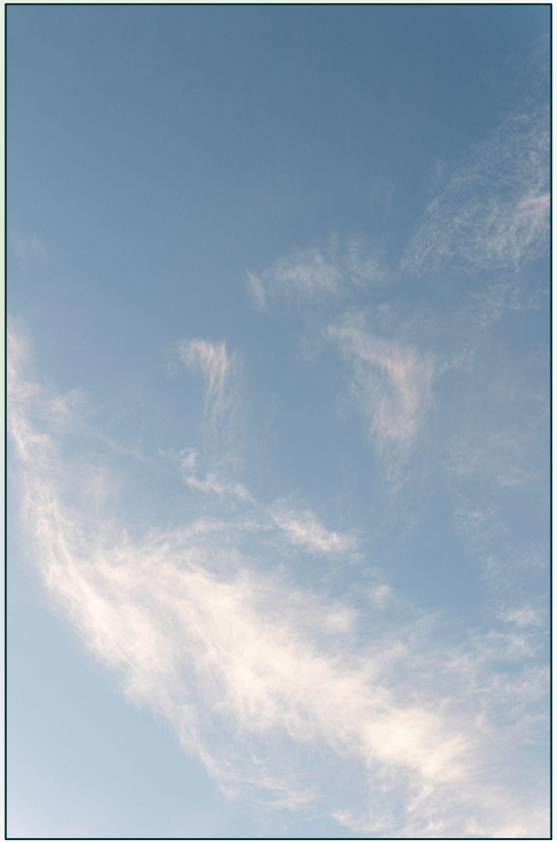
	County	Year	Days with AQI	Good Days	Moderate Days	Unhealthy for Sensitive Groups Days	Unhealthy Days	Very Unhealthy Days	Hazardous Days
2	Buncombe	2000	260.0	129.0	110.0	15.0	6.0	0.0	0.0
3	Buncombe	2001	253.0	141.0	100.0	11.0	1.0	0.0	0.0
4	Buncombe	2002	260.0	144.0	83.0	27.0	6.0	0.0	0.0
5	Buncombe	2003	303.0	178.0	119.0	6.0	0.0	0.0	0.0
6	Buncombe	2004	357.0	187.0	166.0	4.0	0.0	0.0	0.0
7	Buncombe	2005	362.0	192.0	159.0	10.0	1.0	0.0	0.0
8	Buncombe	2006	364.0	182.0	177.0	5.0	0.0	0.0	0.0
9	Buncombe	2007	344.0	161.0	173.0	10.0	0.0	0.0	0.0

AIR QUALITY INDEX ANALYSIS (AQI)

Here is where your presentation begins

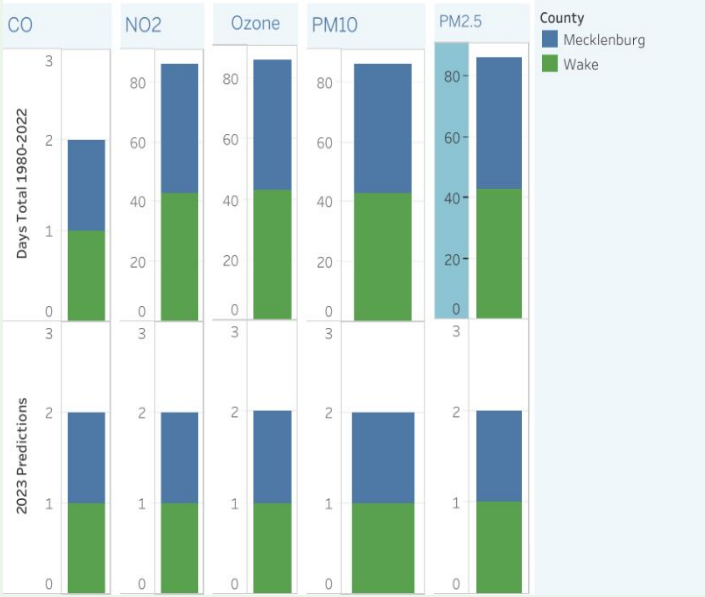
Visualizations and Analysis

3



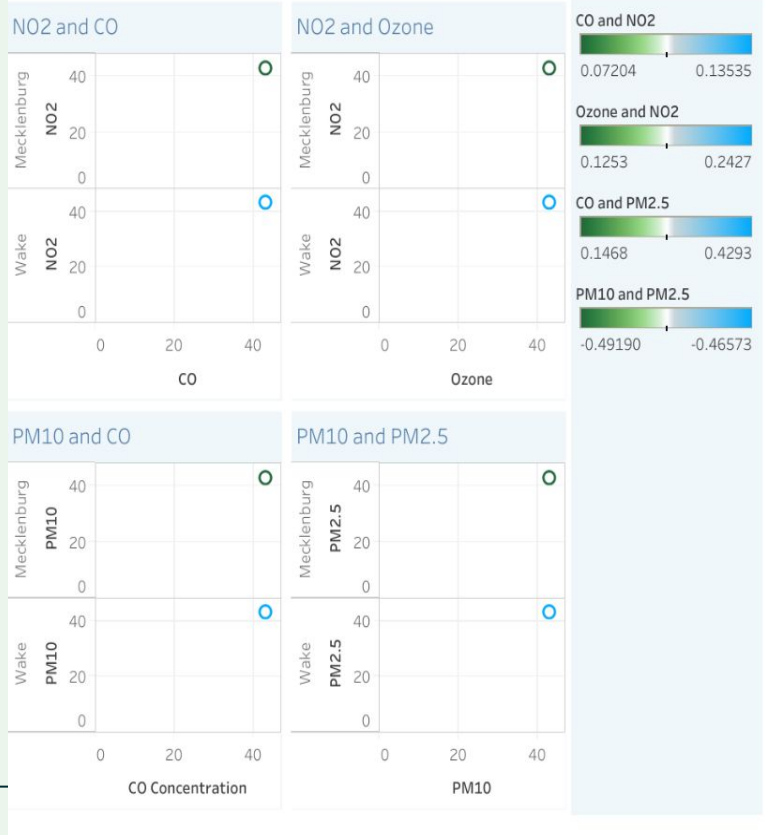
Environmental Data Analysis: Mecklenburg and Wake Counties

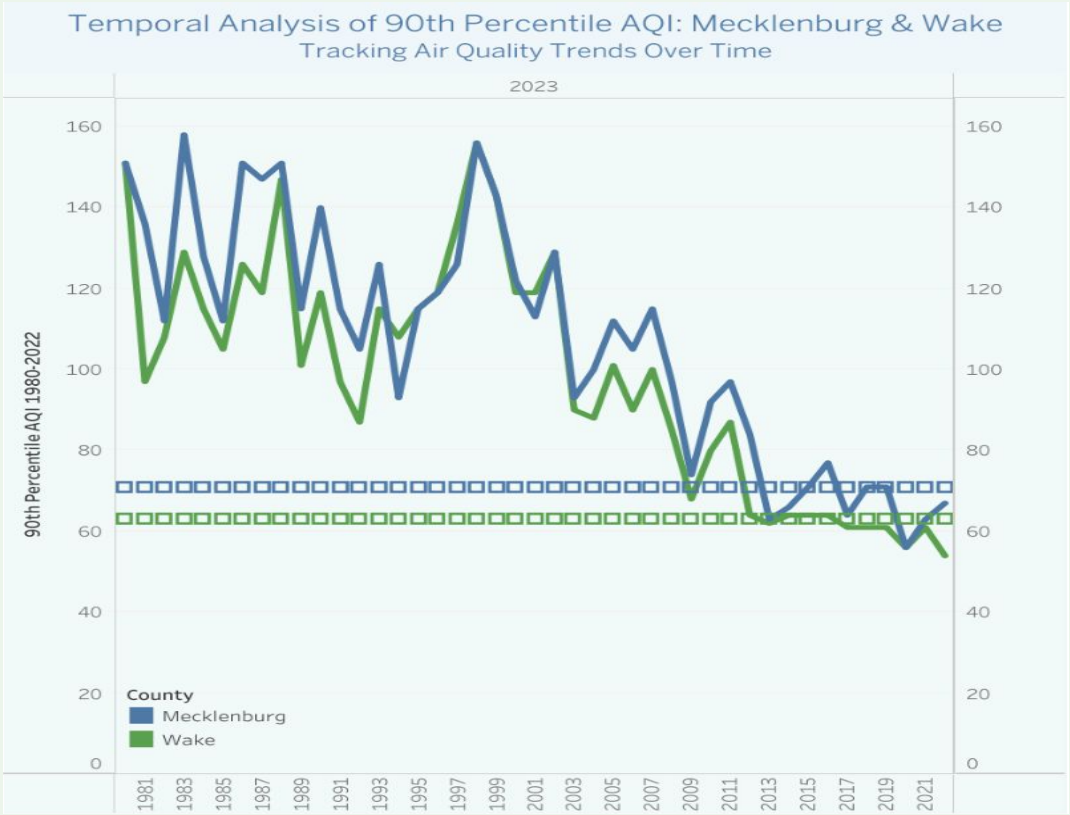
Past Patterns and Future Projections of Exposure Levels

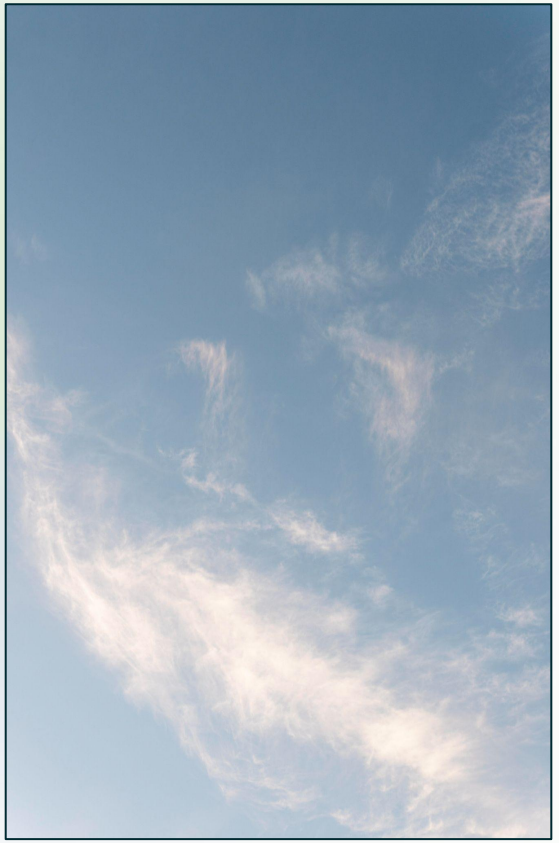


County-Wide Pollution Correlations: Mecklenburg and Wake Counties

Exploring Relationships in Exposure Levels




Temporal Analysis of 90th Percentile AQI: Mecklenburg & Wake
Tracking Air Quality Trends Over Time
2023
90th Percentile AQI 1980-2022
160
140
120
100
80
60
40
20
0
County
Mecklenburg
Wake
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021



4

The ML Model

Model Overview: Linear Regression

Target Variable - Percent of Unhealthy Days in 2023 for Charlotte and Raleigh

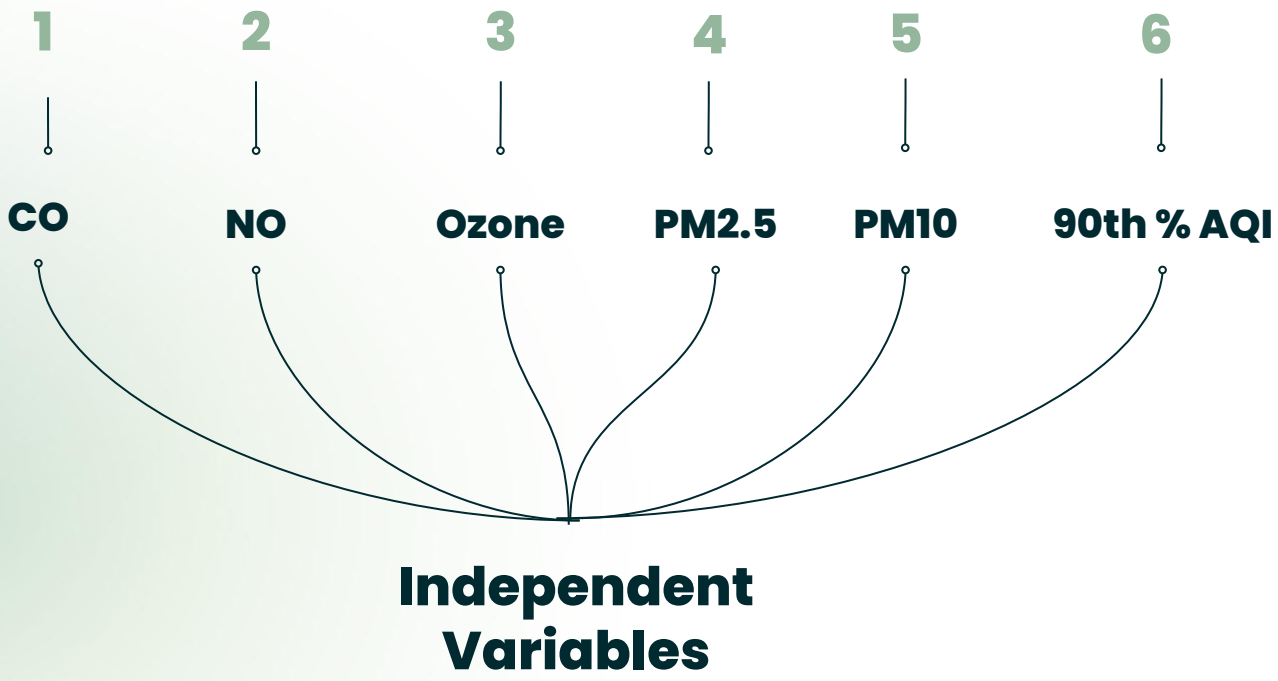
County	Year	Days CO	Days NO2	Days Ozone	Days PM2.5	Days PM10	90th Percentile AQI	Predicted_Unhealthy_Days_Percentage
Mecklenburg	2023	0	1	218	108	0	71.0	3.021587
Wake	2023	0	2	175	148	0	63.0	0.926351

1. Ability to decipher complex patterns
2. Identifies relationships within large datasets

Features and Training

Unhealthy Days %

Percent of Unhealthy Days



Model Results

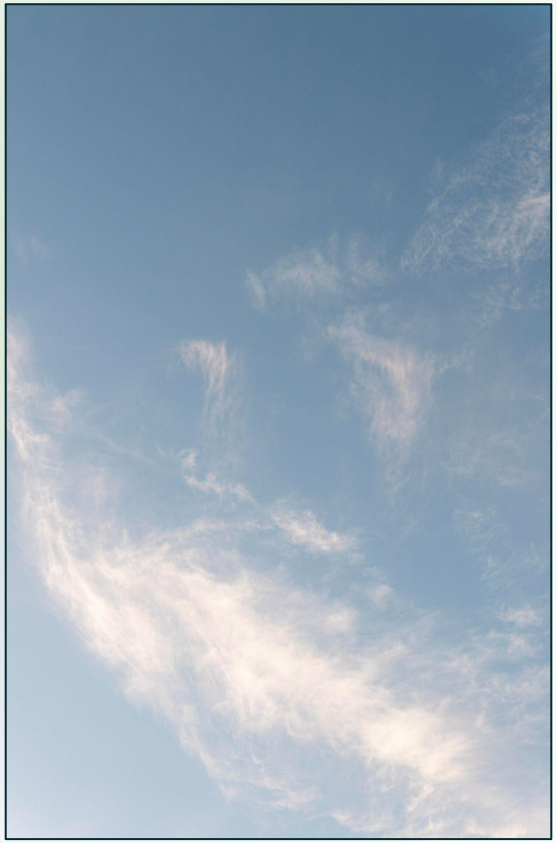
87%

R- Squared Value

County	Year	Days CO	Days NO2	Days Ozone	Days PM2.5	Days PM10	90th Percentile AQI	Predicted_Unhealthy_Days_Percentage
Mecklenburg	2023	0	1	218	108	0	71.0	3.021587
Wake	2023	0	2	175	148	0	63.0	0.926351

Conclusions

5



Final Conclusion

Final Analysis: Our air is getting healthier!

Predicted Unhealthy/ Healthy Days Result:

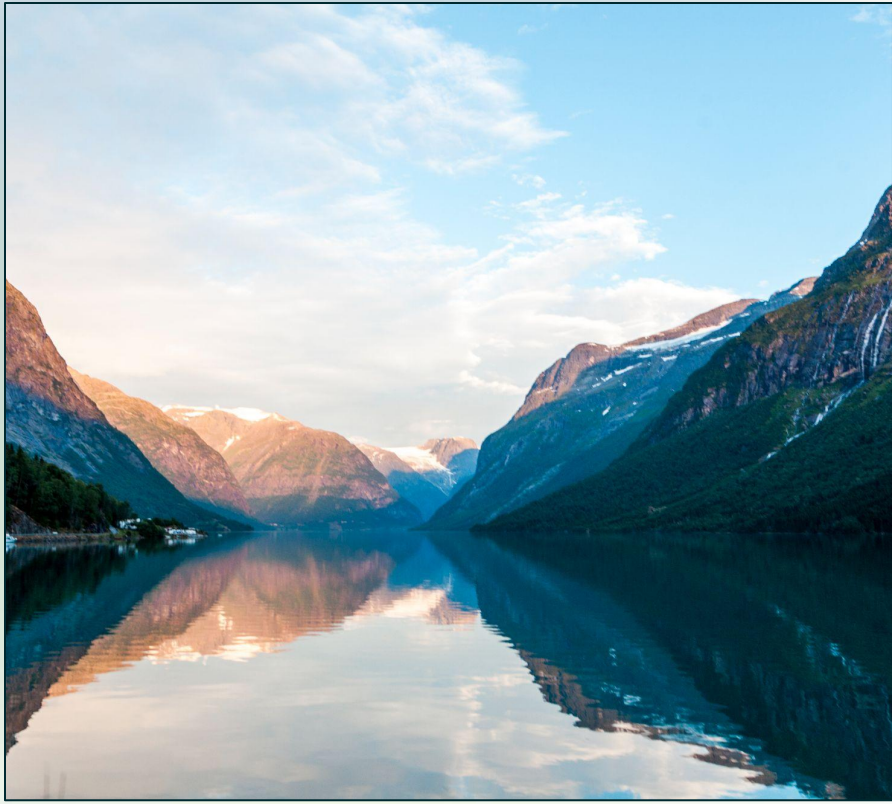
- 97% Healthy and 3% Unhealthy for Charlotte
- 99% Healthy and 1% Unhealthy for Raleigh

Reasons as to Why?

- Traffic and Transportation
- Population Density

THANKS

DO YOU HAVE ANY QUESTIONS?



CREDITS: This presentation template was created by **Slidesgo**, and includes icons by **Flaticon** and infographics & images by **Freepik**

RESOURCES

All information was gathered from the United States Environmental Protection Agency. Here are a few pages that were the most useful:

- Air Data Basic Information
- About Air Data Reports
- Download Daily Data
- U.S. Census Bureau