Analyzing the Relationship between Ambient Ozone and $PM_{2.5}$ Levels and Annual Average Daily Traffic in Florida

Karen Sem
Department of Environmental Engineering Sciences, University of Florida

INTRODUCTION

- Ozone (O_3) and $PM_{2.5}$ are designated Criteria Air Pollutants by the U.S. Environmental Protection Agency (EPA) due to their detrimental effects on public health and welfare.[1]
- Knowledge of O_3 and $PM_{2.5}$ sources can assist development of policies and control mechanisms that prevent or mitigate their exposure to communities.
  - One notable anthropogenic source of O_3 and $PM_{2.5}$ is road traffic emissions.[2,3]
  - Higher road traffic is associated with more densely populated areas.
- ***Objectives:***
  - Determine spatial and temporal distribution of O_3 and $PM_{2.5}$ in Florida between 2010-2020.
  - Determine relationship between average annual O_3/$PM_{2.5}$ concentrations, average annual daily traffic (AADT), and population density in Florida during 2020.

DATA COLLECTION & ANALYSIS

- Data collected:
  - Major roads and AADT recorded in 2020 by Florida Department of Transportation (FDOT)
  - Average annual O_3 and $PM_{2.5}$ concentrations recorded from 2010-2020 in Florida by air quality (AQ) monitors operated by U.S. EPA
  - Population and population density of census-designated places (CDPs) in Florida calculated by U.S. Census Bureau
- Spatiotemporal analysis:
  - Determine if urban and rural O_3/$PM_{2.5}$ concentrations are significantly different
  - Calculate average percentage change in O_3/$PM_{2.5}$ populations measured in urban and rural CDPs from 2010-2020
- Descriptive analysis:
  - Calculate total AADT of roads within 20 km of each monitor
  - Develop linear regression models for O_3/$PM_{2.5}$ concentrations vs. nearby AADT or population density
  - Use Cox regression tests to compare linear regression models for different relationships

RESULTS

- Between 2010-2020, average annual O_3 concentrations decreased by 13.7%, while $PM_{2.5}$ concentrations decreased by 0.95% (Figure 1).
- In 2020, average annual O_3 and $PM_{2.5}$ concentrations were not significantly different between urban and rural (<2,500 people) CDPs.
- Average annual O_3 and $PM_{2.5}$ concentrations are weakly correlated with nearby AADT and with population density (Figure 3).

Figure 1. Average annual concentrations of O_3 (in ppm) and $PM_{2.5}$ (in μg/m^3) from 2010-2020.

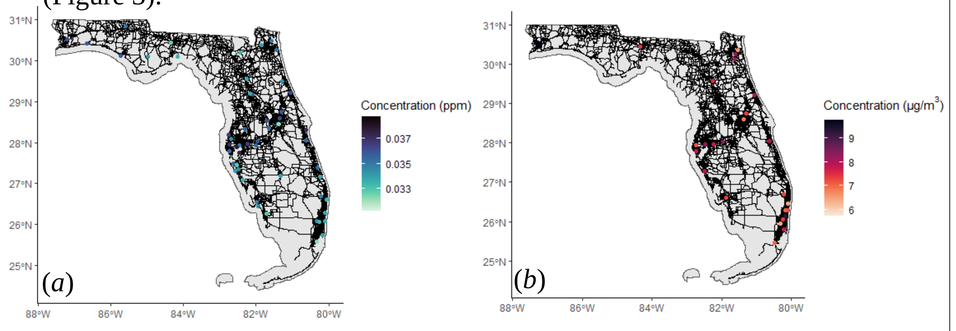

Figure 2. AQ monitors distributed across Florida's major roadways (shown in black) and their average (*a*) O_3 and (*b*) $PM_{2.5}$ concentrations in 2020.

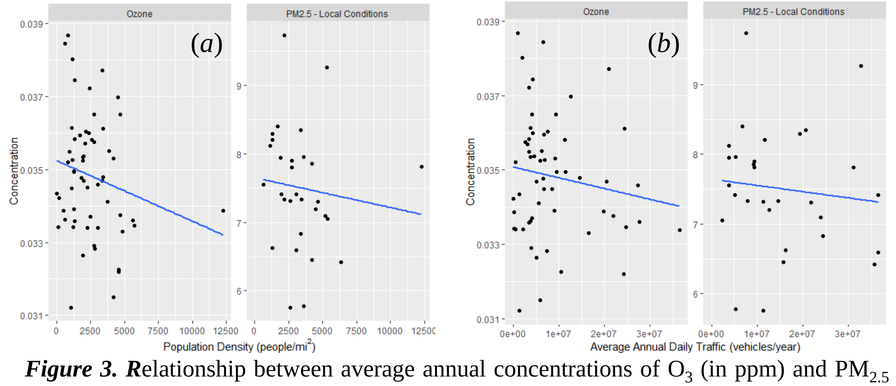

Figure 3. Relationship between average annual concentrations of O_3 (in ppm) and $PM_{2.5}$ (in μg/m^3) recorded by AQ monitors in 2020 and (*a*) population density and *(b)* AADT.

DISCUSSION

- O_3 and $PM_{2.5}$ concentrations change in a significantly different manner with respect to AADT ($\alpha = 0.90$).
- While O_3 concentrations change in a significantly different manner ($\alpha = 0.90$) with respect to AADT and population density, $PM_{2.5}$ changes in a significantly similar manner.
- The different trends in O_3 and $PM_{2.5}$ distribution and their change in concentrations with AADT or population density can be attributed to their different mechanisms of formation from road traffic emissions.
  - Ozone is formed from reactions between nitrous oxides (NO_x) and volatile organic compounds (VOCs) emitted from car, truck, and motorcycle engines.[2]
  - $PM_{2.5}$ is largely formed from road dust generated from tires and from photochemical reactions of VOCs.[3]
- $PM_{2.5}$ generation from road traffic emissions is more directly tied to the number of vehicles on the road.

CONCLUSIONS & APPLICATIONS

- Average annual O_3 and $PM_{2.5}$ concentrations' weak correlation to AADT indicates that other sources are major contributors to local ambient levels in Florida.
- The insignificant difference between O_3 and $PM_{2.5}$ concentrations in rural and urban CDPs suggests that these sources are independent of population or anthropogenic activity.
- A greater understanding of the sources contributing to O_3 and $PM_{2.5}$ generation in a region can be gained by air monitoring at a smaller spatial scale.

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