Sources and Health Effects of Reactive Oxygen Species in Atlanta Air Pollution

Josephine Bates
Civil and Environmental Engineering Department, Georgia Institute of Technology

Introduction
Ambient fine particulate matter (PM$_{2.5}$) in the air has been shown to cause adverse health effects. Reactive oxygen species (ROS) found in PM$_{2.5}$ are suspected to contribute significantly to these health effects; however, lack of data and modeling capability of these species have prevented researchers from definitively showing a link between ROS and human health.

Objectives
- Create model for ROS in the atmosphere using one year of field observations
- Investigate link between ROS and human health
- Use model to simulate daily ambient ROS concentrations over a 12-year period
- Create linear regression slope to calculate rate of DTT consumption, or DTT-activity, in nmol min$^{-1} \cdot$ m$^{-3}$
- Analyze data from a 12-year period to assess health impacts

Field Study
- Map of measurement locations
- Measurements of water-soluble PM$_{2.5}$ taken from June 2012 – July 2013
- Urban sites: Jefferson Street in Atlanta, Georgia Tech, roadside site near the Downtown Connector, Birmingham
- Rural sites: Yorkville, Cartersville

Data Collection

Overview

Model Development and Application

Health Study

Analytical Methods

FIGURE 3: Automated system for measuring DTT

Process:
1. Combine PM$_{2.5}$ sample with 100 µl of DTT
2. Measure amount of DTT consumed at several time steps
3. Create linear regression slope to calculate rate of DTT consumption, or DTT-activity, in nmol min$^{-1} \cdot$ m$^{-3}$

Source Impact and ROS Models

I. Source Apportionment using Chemical Mass Balance (CMB)

$$ C_i = \sum_j f_{ij} S_j + e_i $$

Species used: Elemental carbon, organic carbon, sulfate, ammonia, nitrate, metals

II. Stepwise Linear Regression

$\text{DTT} = 0.1 \text{GV} + 0.04 \text{BURN} + 0.1 \text{CFPP} + 0.02 \text{AMSULF} + 0.05 \text{AMNITR} + 0.01 \text{PMother} \text{DWT}$

Conclusion

This research provides the strongest empirical evidence to demonstrating a significant linkage between ROS and adverse health effects and also provides knowledge on sources of ROS for future policy initiatives.

1) ROS significantly increases the risk of asthma/wheezing attacks
2) Source contributions in DTT-activity exhibit a strong seasonal trend
3) Gas vehicles and biomass burning contribute the most to DTT-activity

Health Impact Modeling and Implications

- The health impact assessment part of this study investigates the effects of 24-hr PM$_{2.5}$ and DTT-activity on human health by exploring the link between concentrations of these species and number of emergency department visits in the Atlanta area for asthma or wheezing
- Covariates controlled for in this model include: season, day of week, holidays, temperature, dew point

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