Development of a Quantitative Accounting Framework for Black Carbon and Brown Carbon from Emissions Inventory to Impacts

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Motivation

- Emissions inventories and air quality models of light adsorbing carbon require parameterization of the radiative properties of emissions
- Current parameterizations of light absorbing carbon emissions do not address the range of variability within sources or control technologies
- Elemental carbon is not a good surrogate for light absorbing carbon for control strategy development nor assessment of control strategy implementation
  - May be OK if limited to absorption at 880 nm
- The light absorbing capacity of carbonaceous aerosol is not a conservative property from the point of emissions to atmosphere

Evolution of Light Adsorbing Carbon from Sources to the Atmosphere

- Evolution of mixing state
- Repartitioning of semi-volatile organics
- Coating of adsorbing aerosol
  - Non-absorbing coatings
  - Absorbing coatings
- Oxidation of organic compounds
  - Gas-phase organics
  - Particle-phase organics

- Important considerations for atmospheric aging and source characterization

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Project Goals

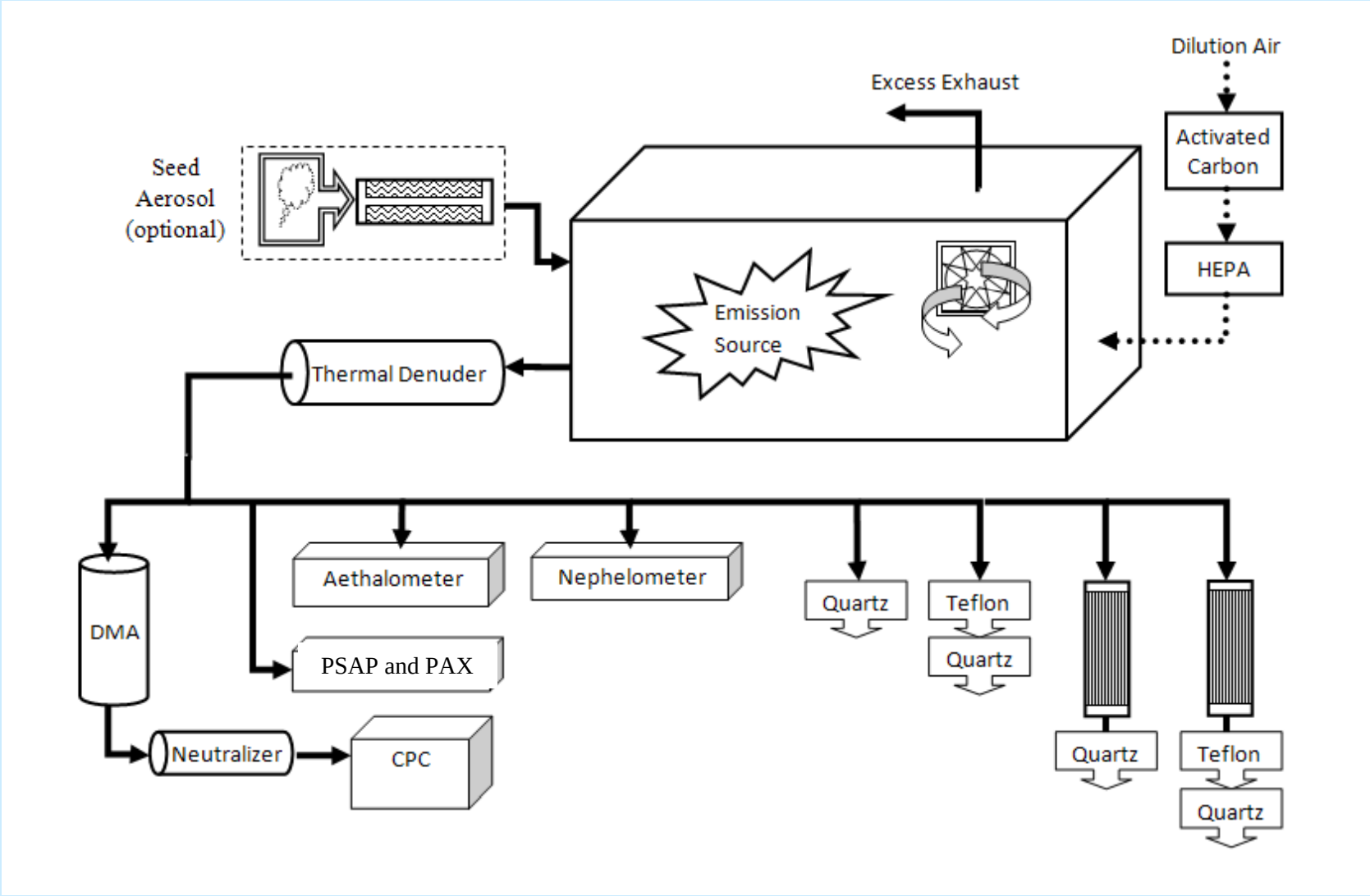
- Overall Goal
  - Development of a quantitative framework for source-receptor relationships for light absorbing carbon and their associated wavelength dependent light absorptivity
- Key Objectives
  - Deconstruct emissions from sources of light absorbing carbon to elucidate the contribution of different emissions components to wavelength dependent absorption
  - Elucidate how the evolution of emissions in plumes impact wavelength dependent absorption
  - Integrate source apportionment models for aerosol components impacting light adsorption with wavelength dependent light absorption closure calculations

Project Strategy

- Source Testing
- Mie theory calculations for source emissions and deconstructed emissions
- Atmospheric measurements
- Mie theory calculations for atmospheric aerosols and deconstructed aerosols
- Develop a source apportionment framework that can address the optical evolution of aerosols and precursors

Source Testing

- Examine key sources of light absorbing carbon:
  - Mobile sources
  - Biomass burning
  - Coal combustion
  - Secondary organic aerosol
- Examine for each source
  - Role of process variables on emissions
  - Optical properties of the organic carbon
  - Optical properties of the elemental carbon
  - Impact of dilution
  - Impact of thermal stripping of organics
- Develop source specific light absorption closure models for measurement conditions and high dilution conditions



Impact of Process Variables

Figure 4
Composition of PM from Diesel Engine
CARB - Mode Test

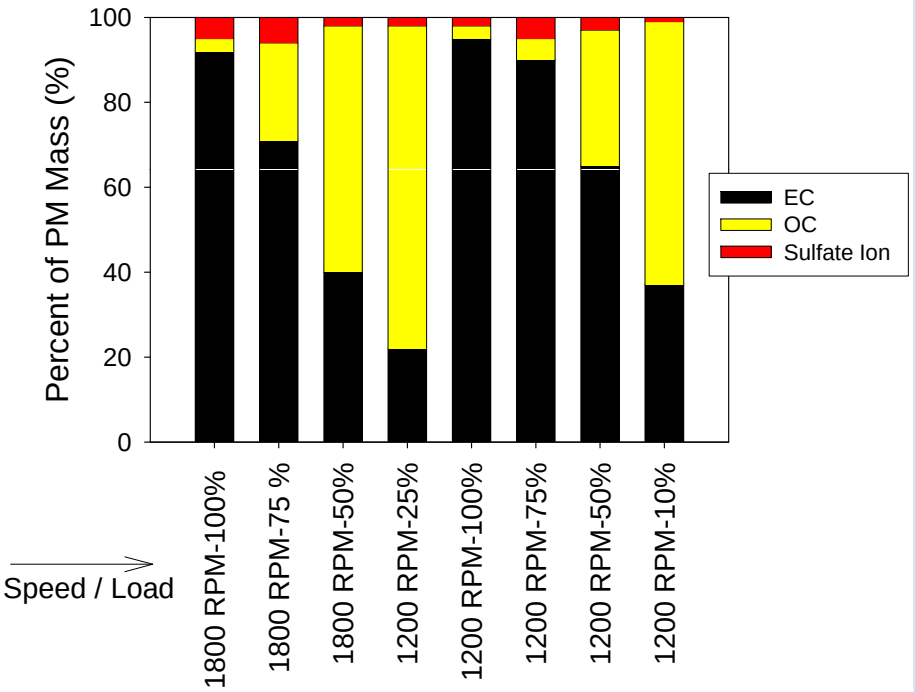
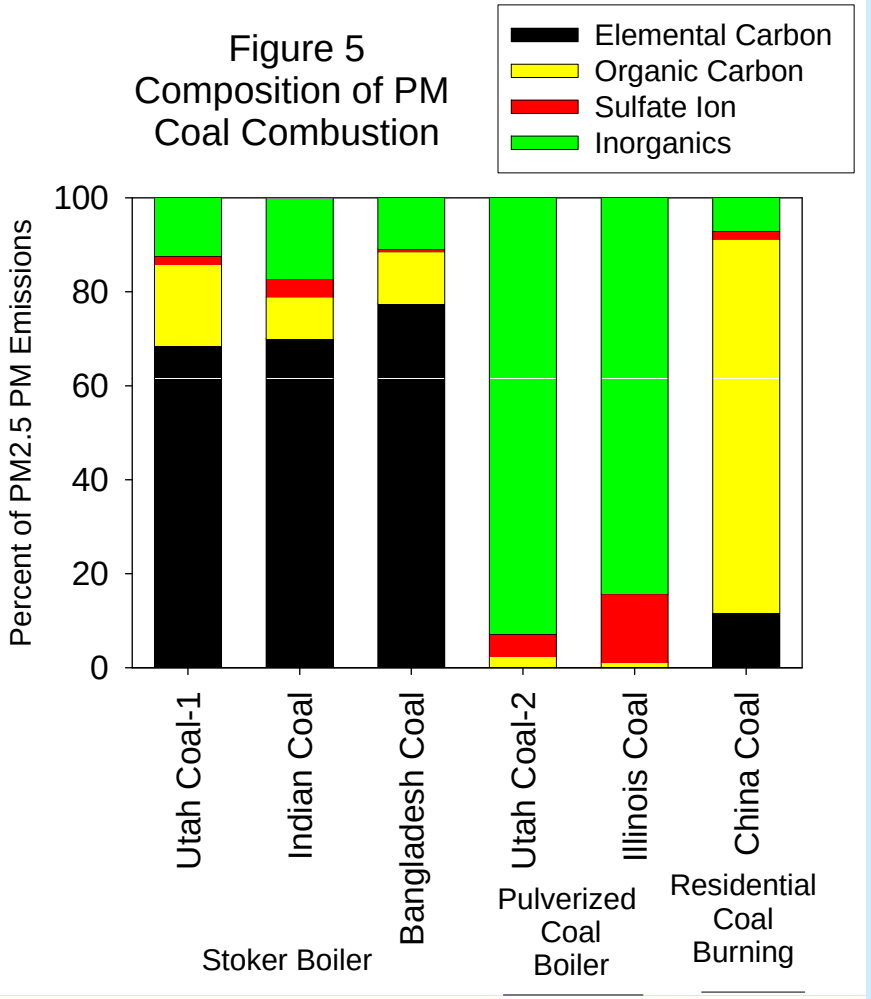


Figure 5
Composition of PM
Coal Combustion



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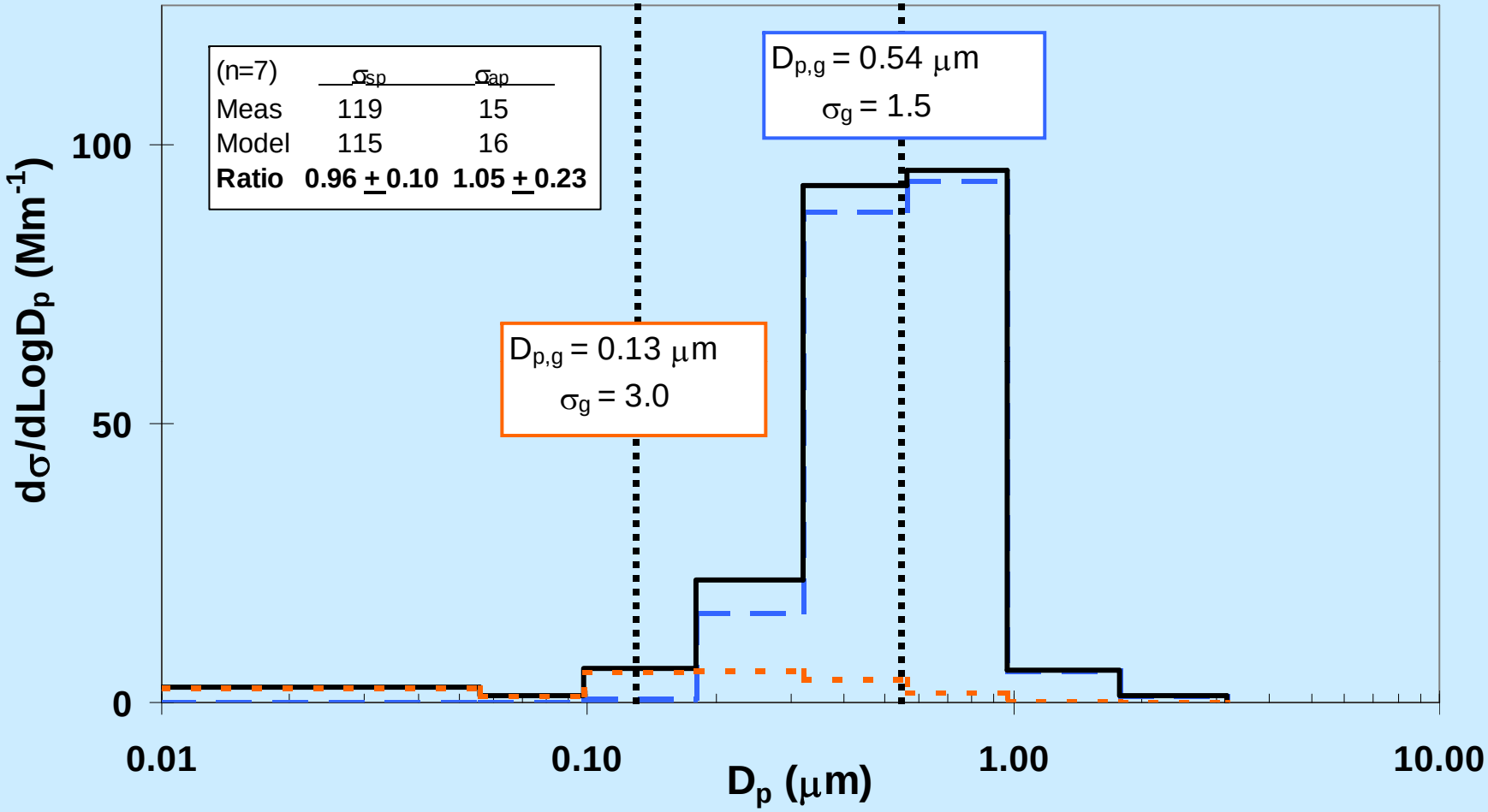
Emissions "Deconstruction"

- Incrementally change emissions to test and further advance Mie theory calculation applied to diluted source emissions
  - Process Variables
  - Size classification
  - Thermal stripping of organics with thermal denuder
  - Extract organic matter for optical analysis
    - Absorption properties in solution
    - Re-aerosolize organic matter for optical analysis

Mie Theory Calculations

- Estimate light scattering and absorption coefficient as a function of particle size and wavelength
- Include mixing state (internal/external) and imaginary refractive indeces from extractable fractions
- Incorporate particle shape if necessary
- Closure experiments for field measurements, laboratory emissions and extractable fractions

Estimated Extinction Distribution (MOUDI+Mie Model) and Measured Extinction (neph+PSAP)



Urban aerosol radiative properties: Measurements during the 1999 Atlanta Supersite Experiment

Christian M. Carrico,[1] Michael H. Bergin, and Jin Xu
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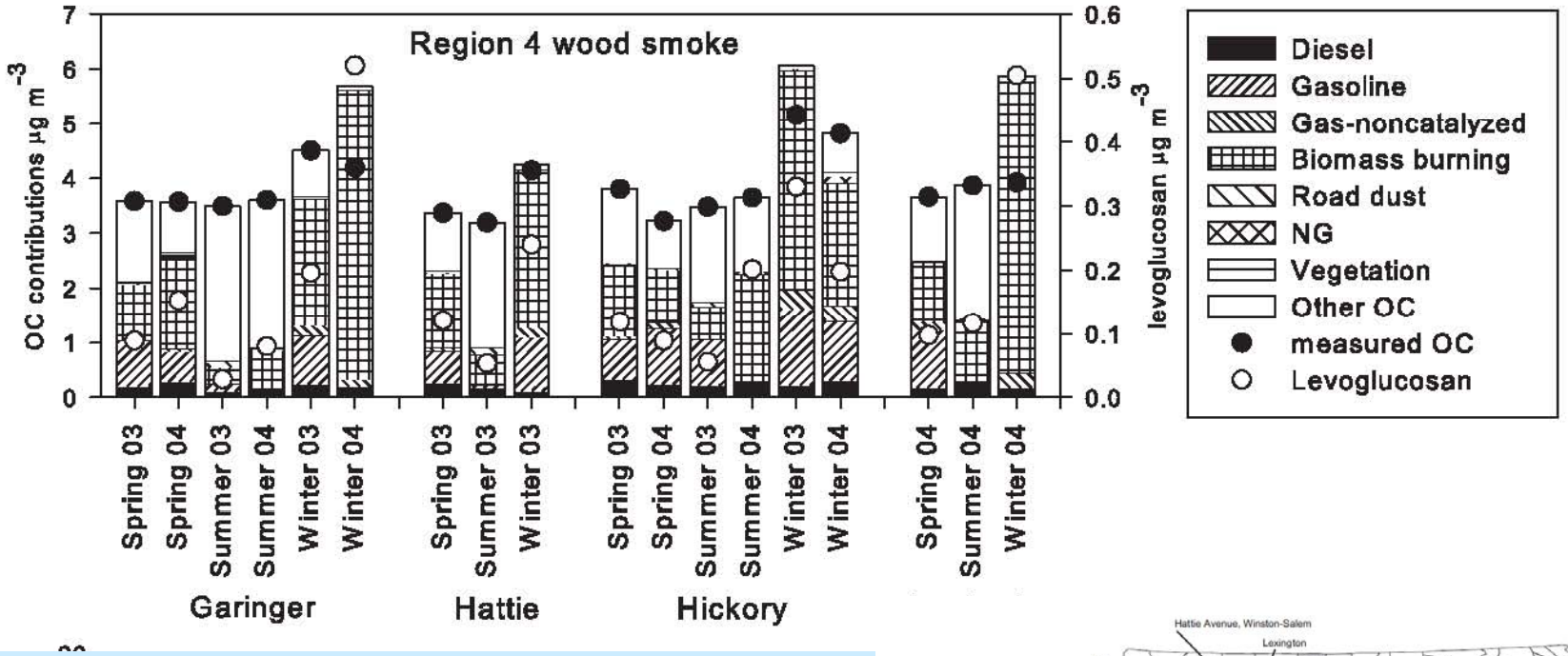
Atmospheric Measurements

- Use sites where we have conducted source apportionment studies in the past and where historical record and optical measurements
  - Atlanta, Georgia
    - SOA and Mobile sources
  - NOAA Earth Systems Research Laboratory, Boone, North Carolina
    - Biomass burning
  - Beijing, China
    - Low temperature coal combustion

Sensitivity of molecular marker-based CMB models to biomass burning source profiles

Rebecca J. Sheesley[a], James J. Schauer[a,b,*], Mei Zheng[c], Bo Wang[c]



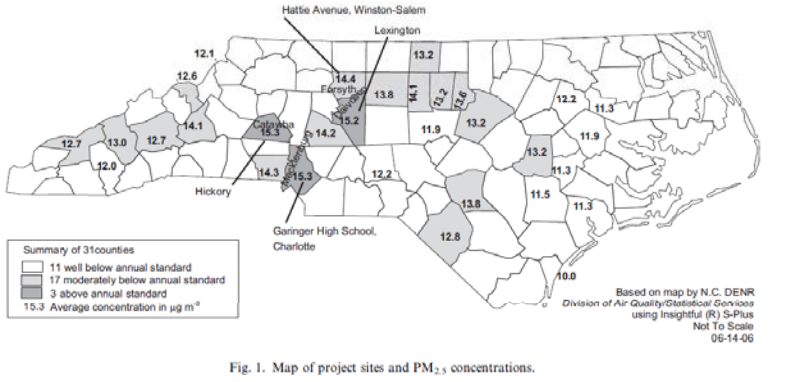


Fig. 1. Map of project sites and $PM_{2.5}$ concentrations.

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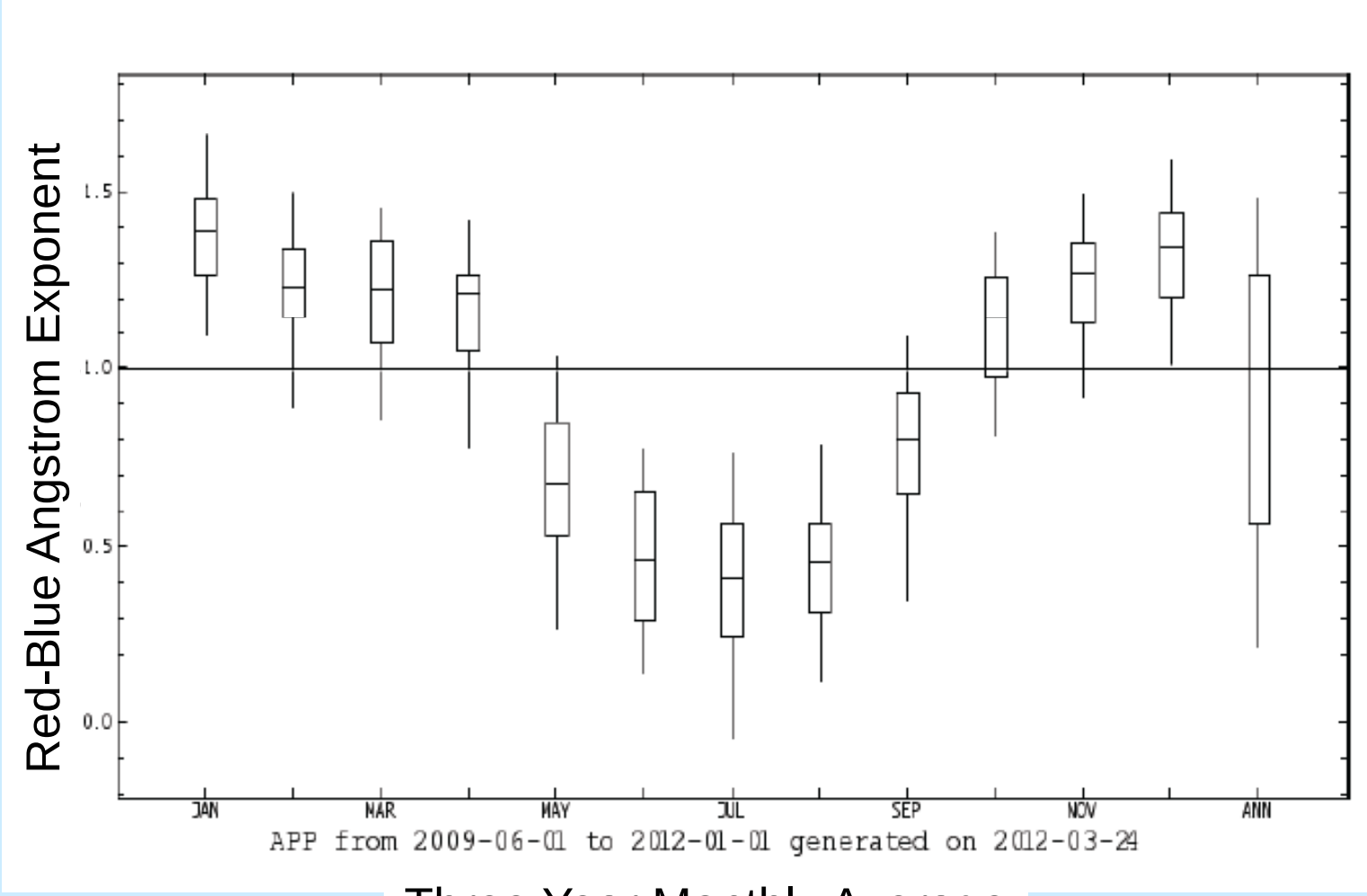
Monthly Absorption Angstrom Exponent for the APP Site (NOAA)



Three Year Monthly Average

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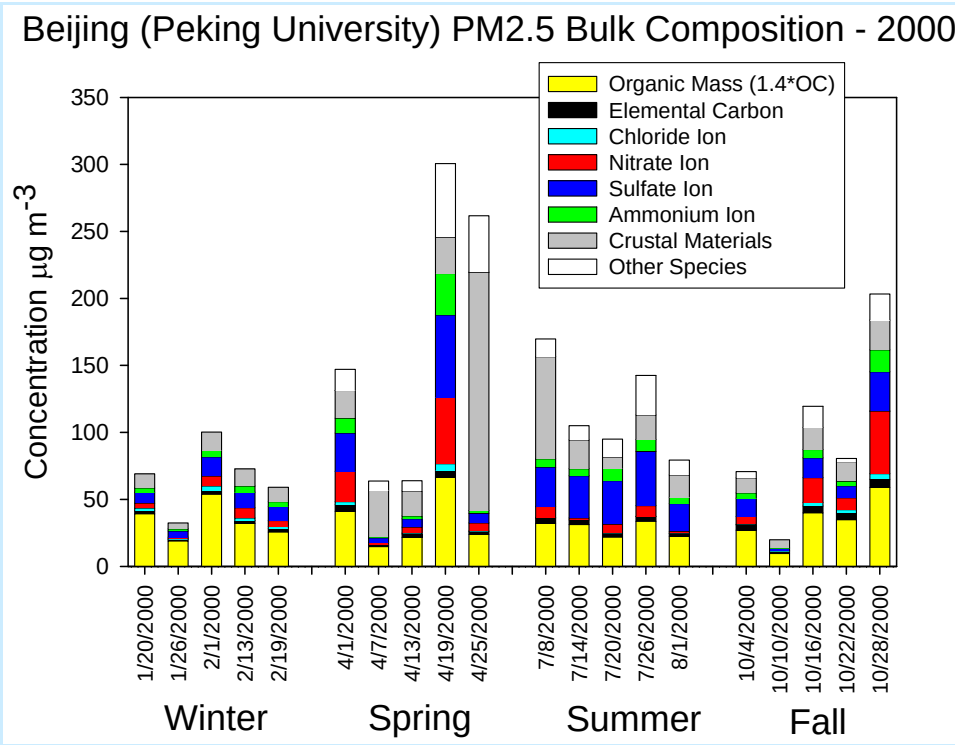

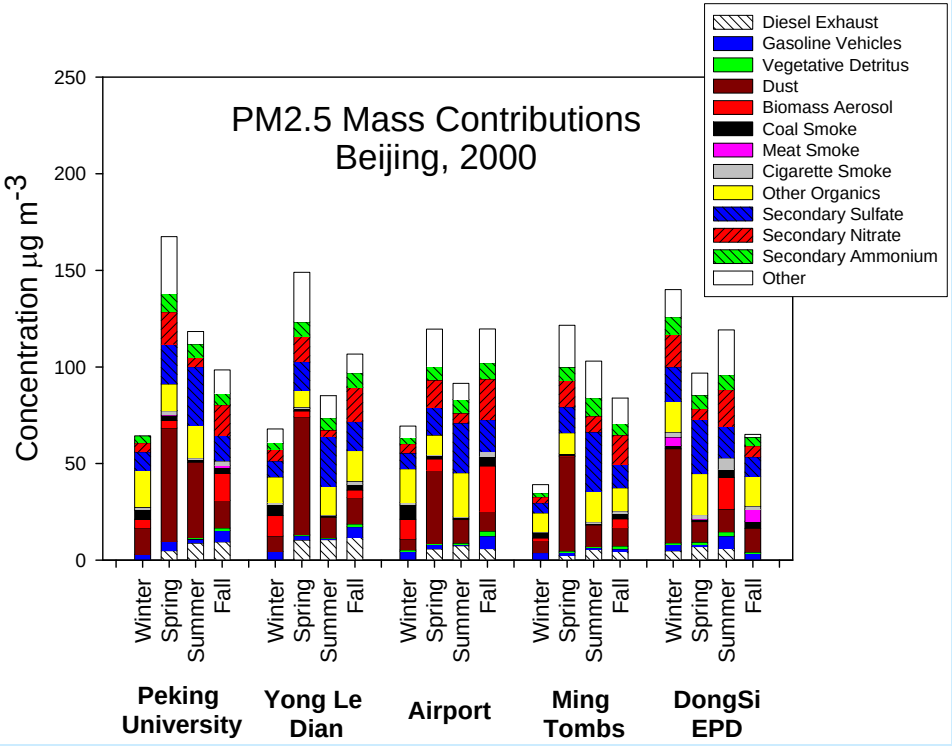

Seasonal trends in PM2.5 source contributions in Beijing, China

Mei Zheng[a,*], Lynn G. Salmon[b], James J. Schauer[c], Limin Zeng[d], C.S. Kiang[d], Yuanhang Zhang[d], Glen R. Cass[a,Φ]

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Progress to Date

- Completed preliminary laboratory testing of integration of chemical and physical characterization tools for source testing
- Completed a series of diesel emissions tests address control technologies and engine operating conditions
  - Designing some laboratory tests to help with interpretation of data
  - Starting chemical measurements and data analysis
- Plan to start atmospheric measurements this summer in Atlanta

Expected Outcomes

- Improved inputs for climate and regional models that need emissions data for the chemical and absorptive properties of particulate matter emissions
- Provide a better and more complete understand the relationship between the optical and chemical properties of the global distribution of aerosols
- Provide a framework to properly account of for emissions inventories of light absorbing carbon to allow proper assessment of control strategies for reducing black carbon emissions
- Provide better understand the link between emissions from air pollution sources and the observed radiative forcing of light absorbing aerosols

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