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Chemical composition and source apportionment of air pollution exposures of rural Chinese women cooking with biomass fuels

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Overview

- Background

  Measurements for epidemiological analysis

- Yunnan example

  Risk of BC&PM and source apportionment

- Bridge the gap between exposures and toxicity

- Implications & Summary

Background

- Black Carbon (BC) sources
  - Incomplete combustions: biomass and fossil fuels, vehicles
- BC measurements and exposure
  - Exposure
  - Health outcomes
    - Blood pressure
    - Fractional Concentration of Exhaled NO (FeNO)
    - …
- BC-risk sources

Exposure measurements

Area sampling

VS

Personal exposure sampling

- Integrate over exposures among different micro-environments
- Capture individuals' normal activities
- More applicable for epidemiological measurements

➔ Measurements for epidemiology

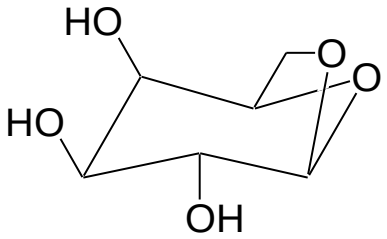
- ⇨ Mass concentration
- ⇨ Chemical composition: Black carbon, ions, metals...
- ⇨ Behavioral factors: Exercising frequency, distance to source…
- ⇨ Health indicator: Blood pressure, FeNO…

Exposure source apportionment

- Results of source characterization may be very different with normal ambient samples

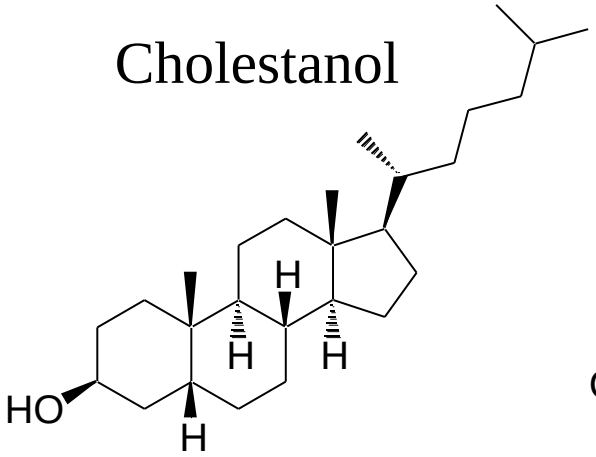
- Typical measurements
  - Bulk composition of particulate matter
    - EC/OC, ions, and metals
  - Organic molecular markers of PM
  - Optical properties of PM
  - Gaseous emissions

Examples of molecular markers

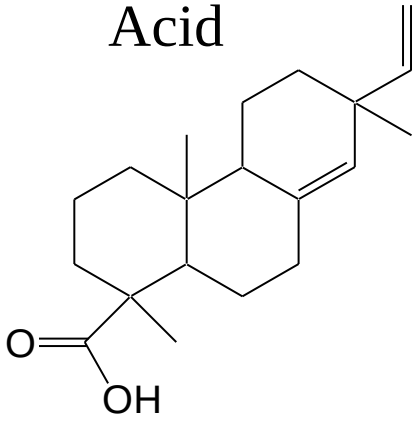


Levoglucosan

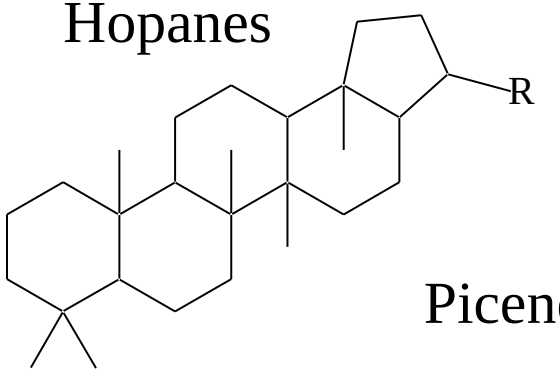
Cholestanol



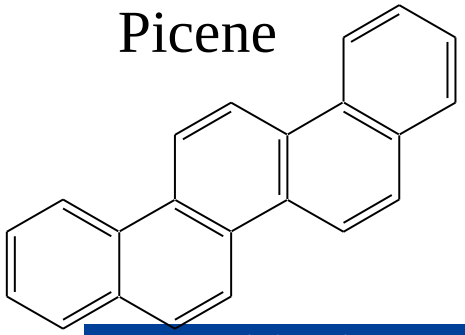
Pimaric Acid



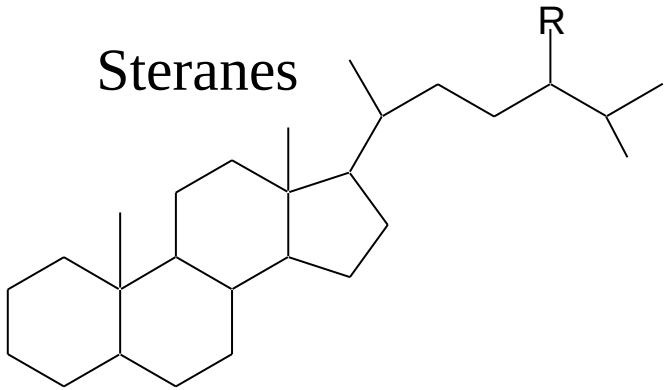
Hopanes



Picene



Steranes



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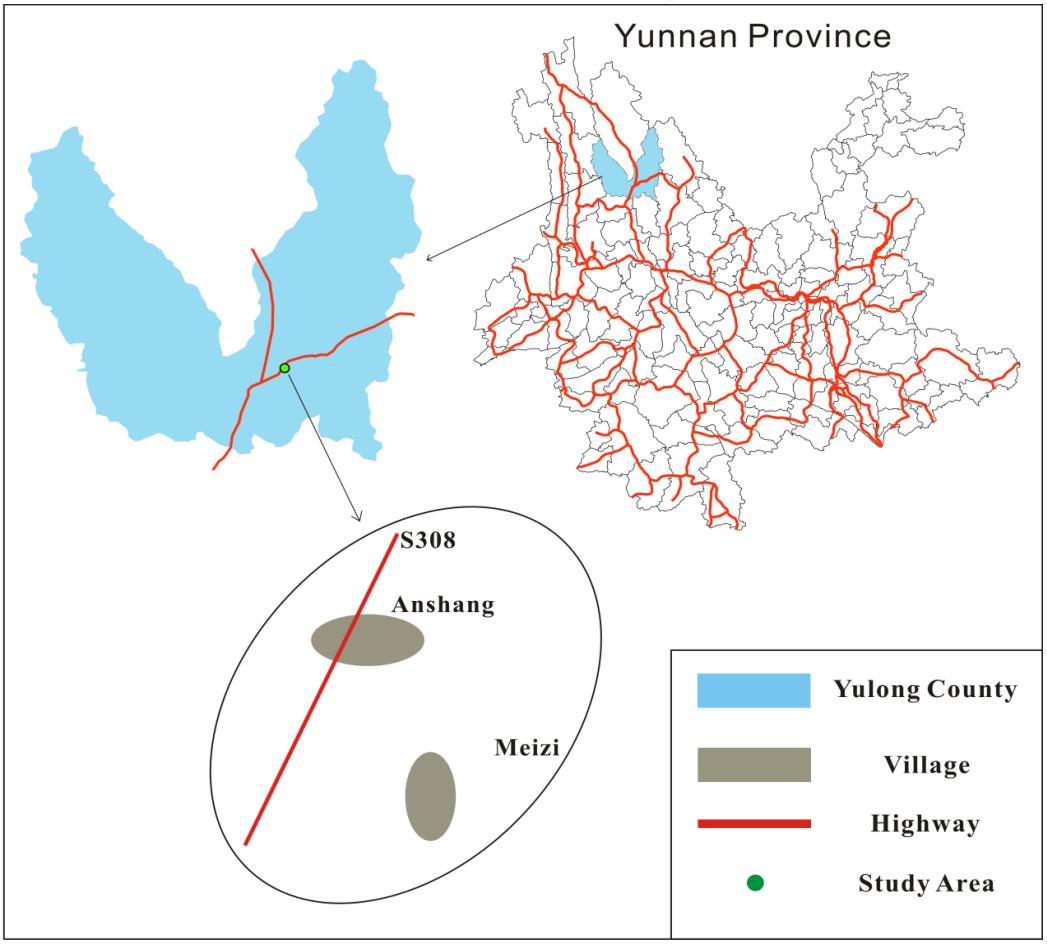
Exposure and health risk

- 280 women
  - Mean age 51.9 y
  - 18% overweight (BMI=25-30 kg/m^2)
  - 4% obese (BMI≥30 kg/m^2)
  - Mean Systolic Blood Pressure (SBP): 120 mmHg
  - Mean Diastolic Blood Pressure (DBP): 72 mmHg
- Exposure
  - PM2.5 mass, BC, OC, Motor Vehicle tracers…

Baumgartner et al, 2014. Highway proximity and black carbon from cook stoves as a risk factor for higher blood pressure in rural China. PNAS 111, 13229-13234.

Exposure sources



Sampling

24-h personal exposures to $PM_{2.5}$ were collected among 81 Chinese women living in two rural villages

Chemical Analysis

More than 100 samples analyzed for WSOC, BC, and molecular markers

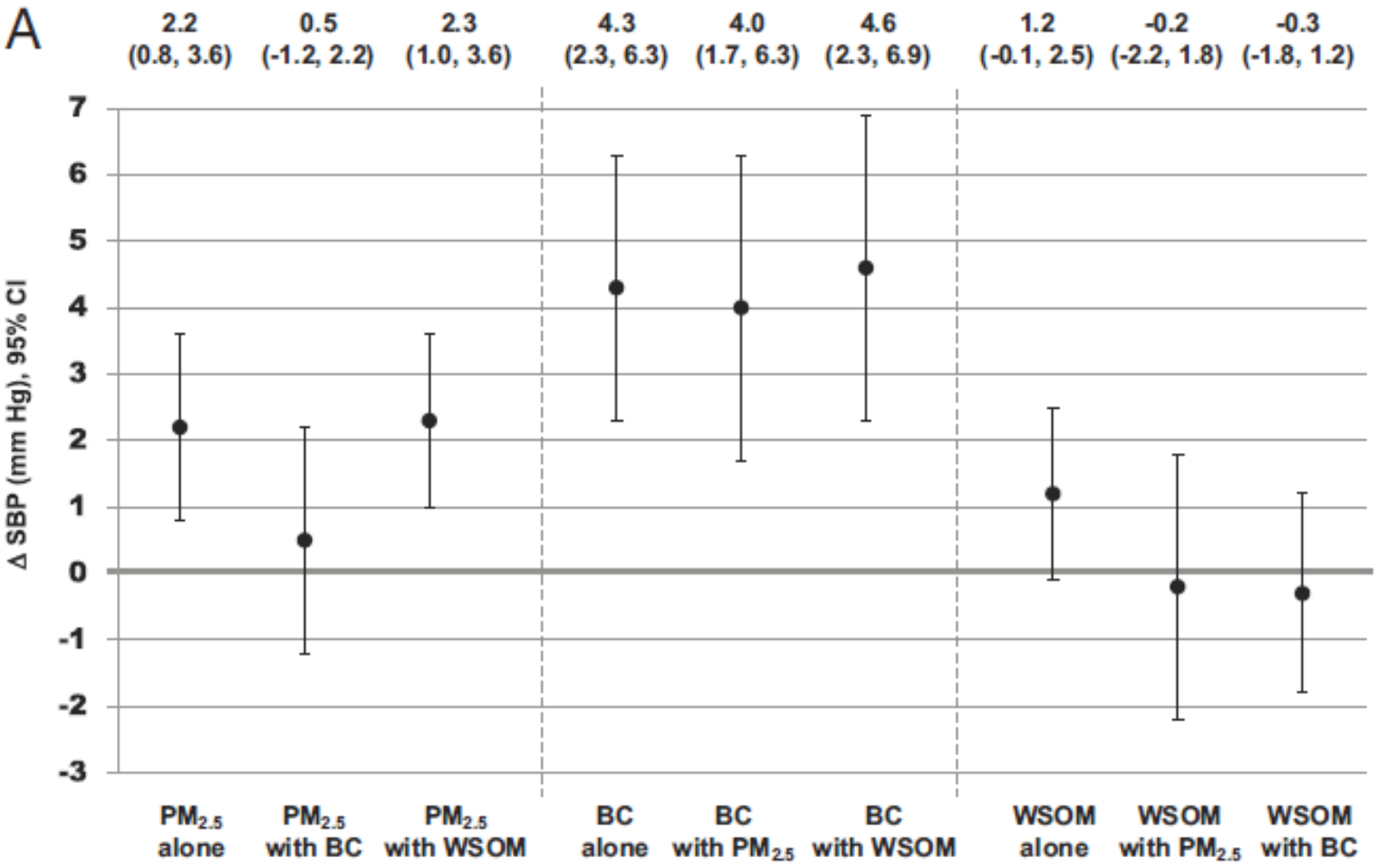
Data Analysis

Positive Matrix Factorization (PMF) – US EPA Source Apportionment Model

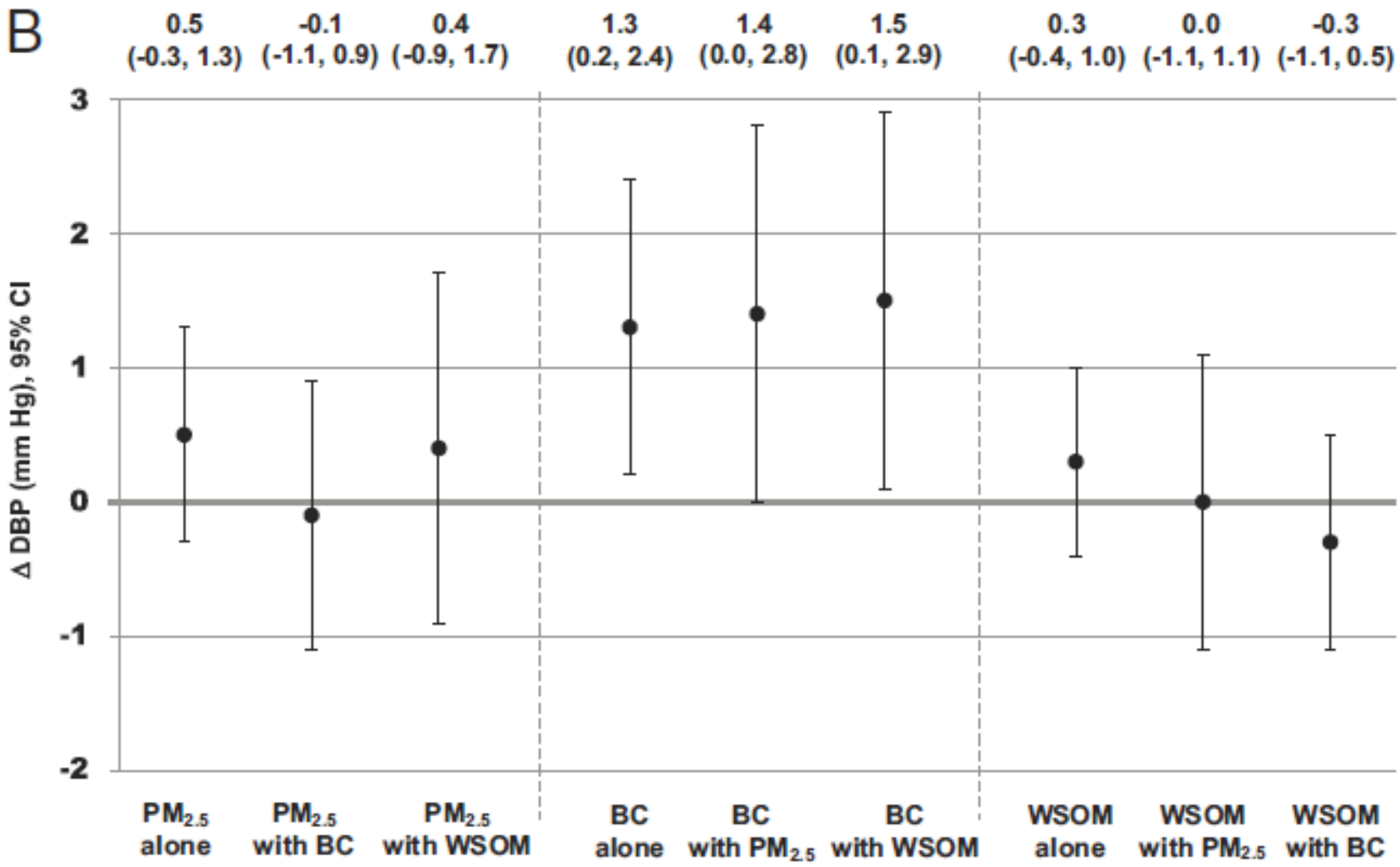
Huang et al, 2015. Source apportionment of air pollution exposures of rural Chinese women cooking with biomass fuels. Atmospheric Environment 104, 79-87

Yunnan Example

PM, BC, WSOM vs SBP



PM, BC, WSOM vs DBP

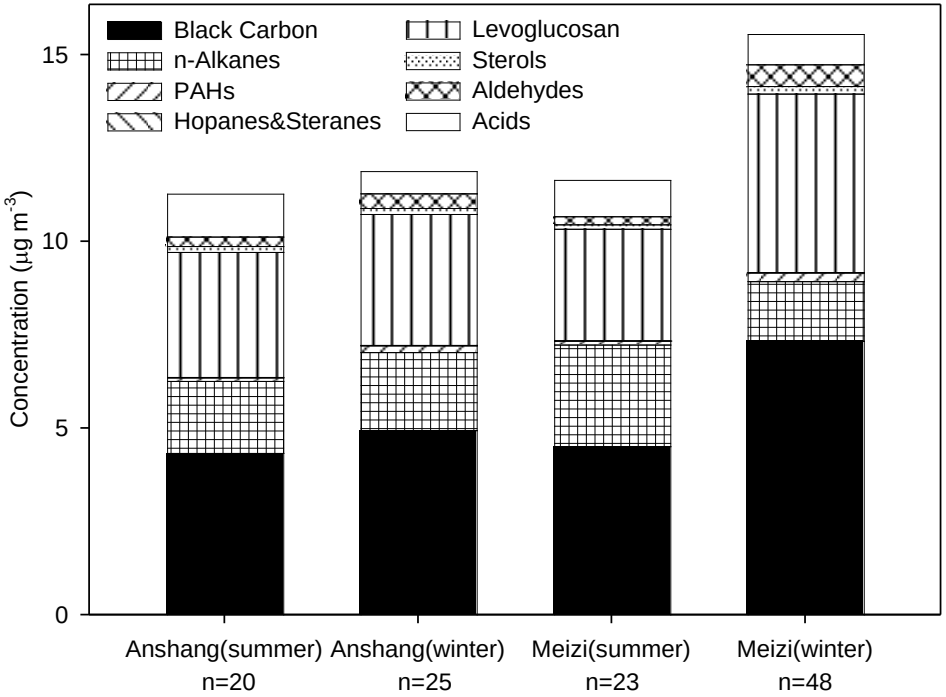


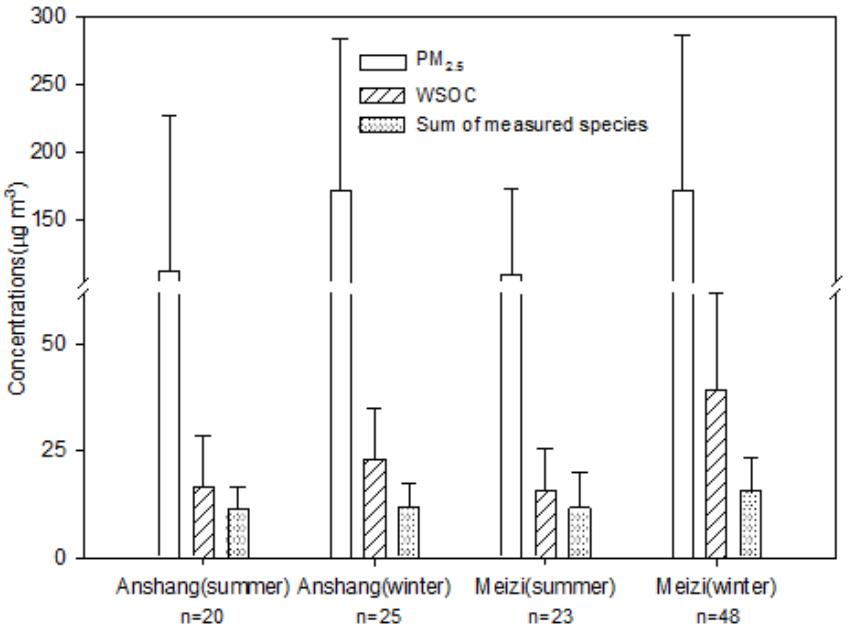
Meaning of BC

- ➔BC may be a useful indicator of the cardiovascular health;
- ➔BC is more strongly linked with health than PM;
- ➔The cardiovascular effect of BC from biomass smoke may be stronger if there is co-exposure to motor vehicle emissions.

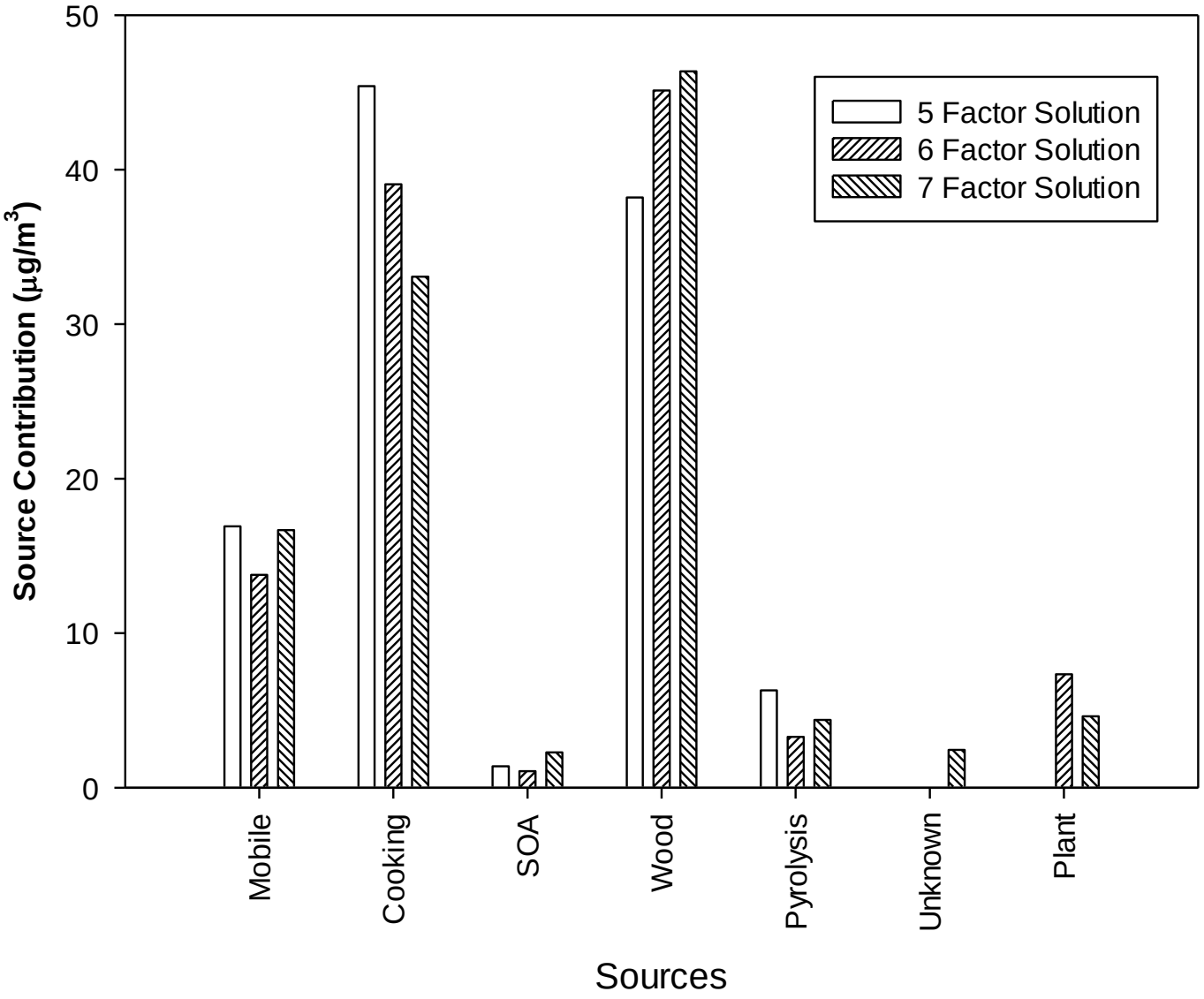
Baumgartner et al, 2014. Highway proximity and black carbon from cook stoves as a risk factor for higher blood pressure in rural China. PNAS 111, 13229-13234.

Spatial and seasonal variation in molecular markers

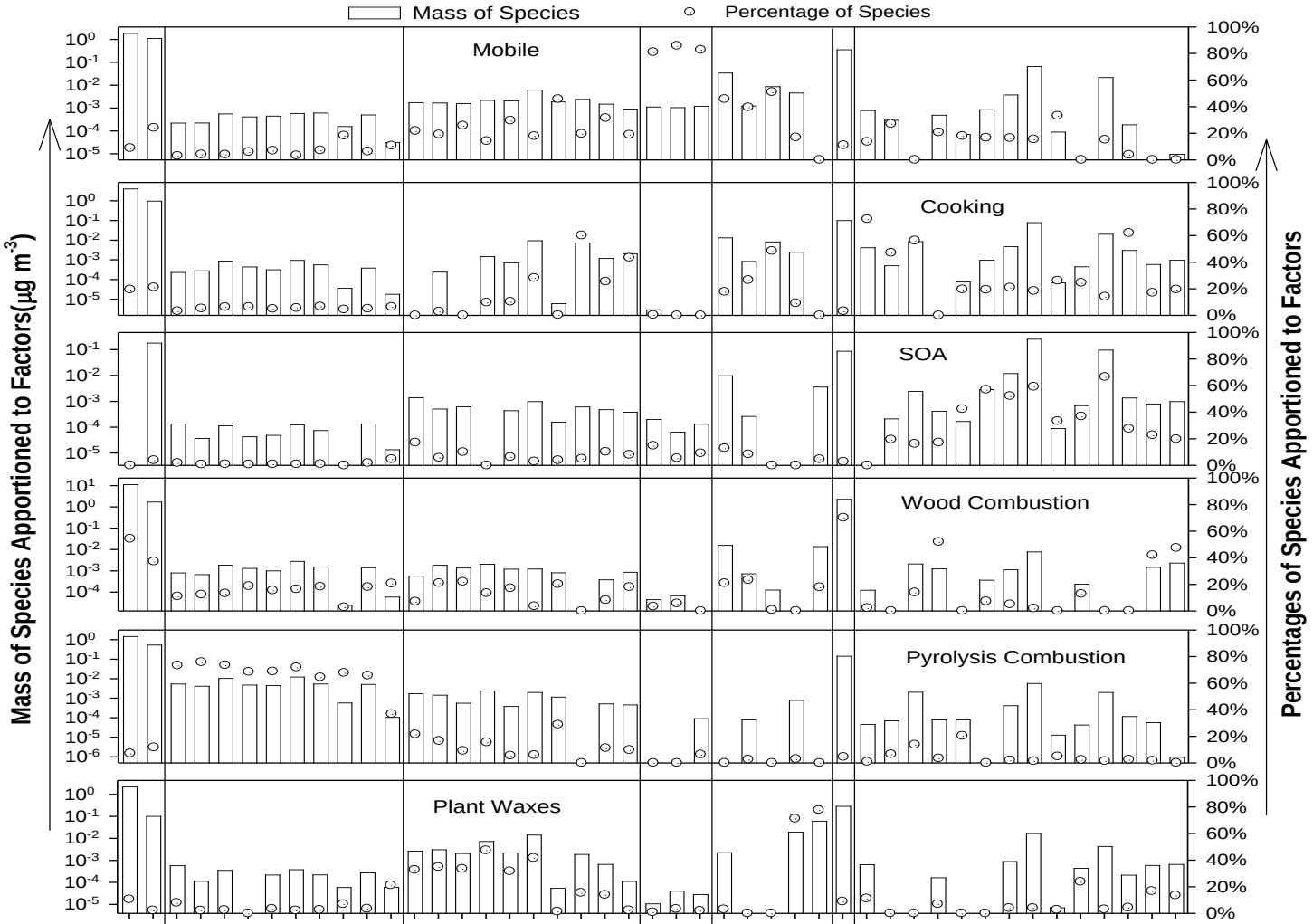




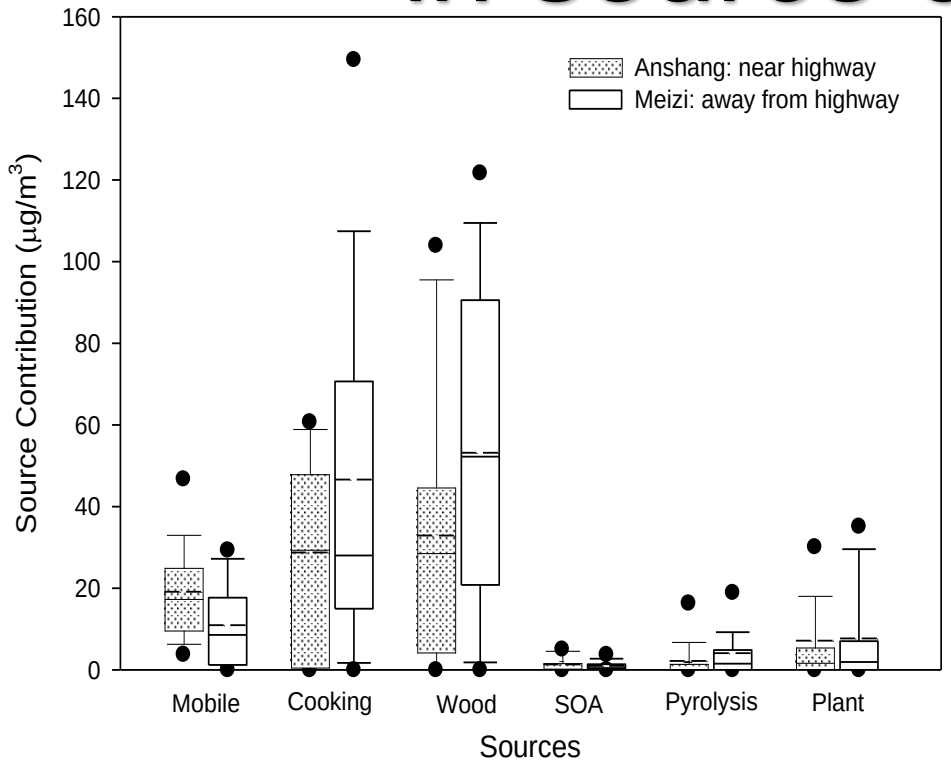
Determination of factor numbers



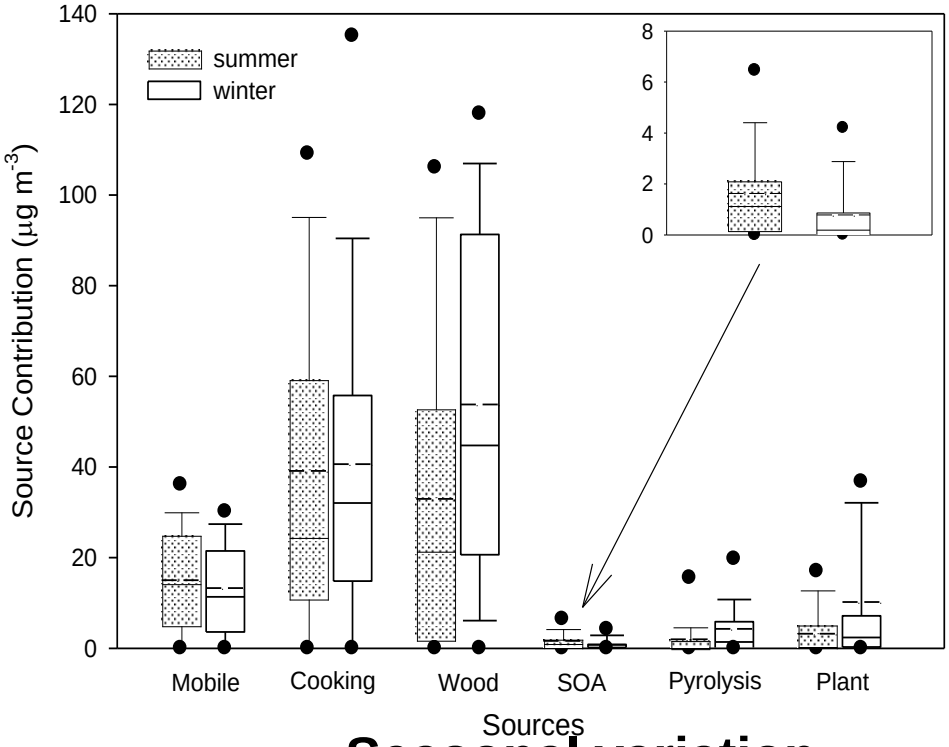
Source profiles



Spatial and seasonal variations in source contributions

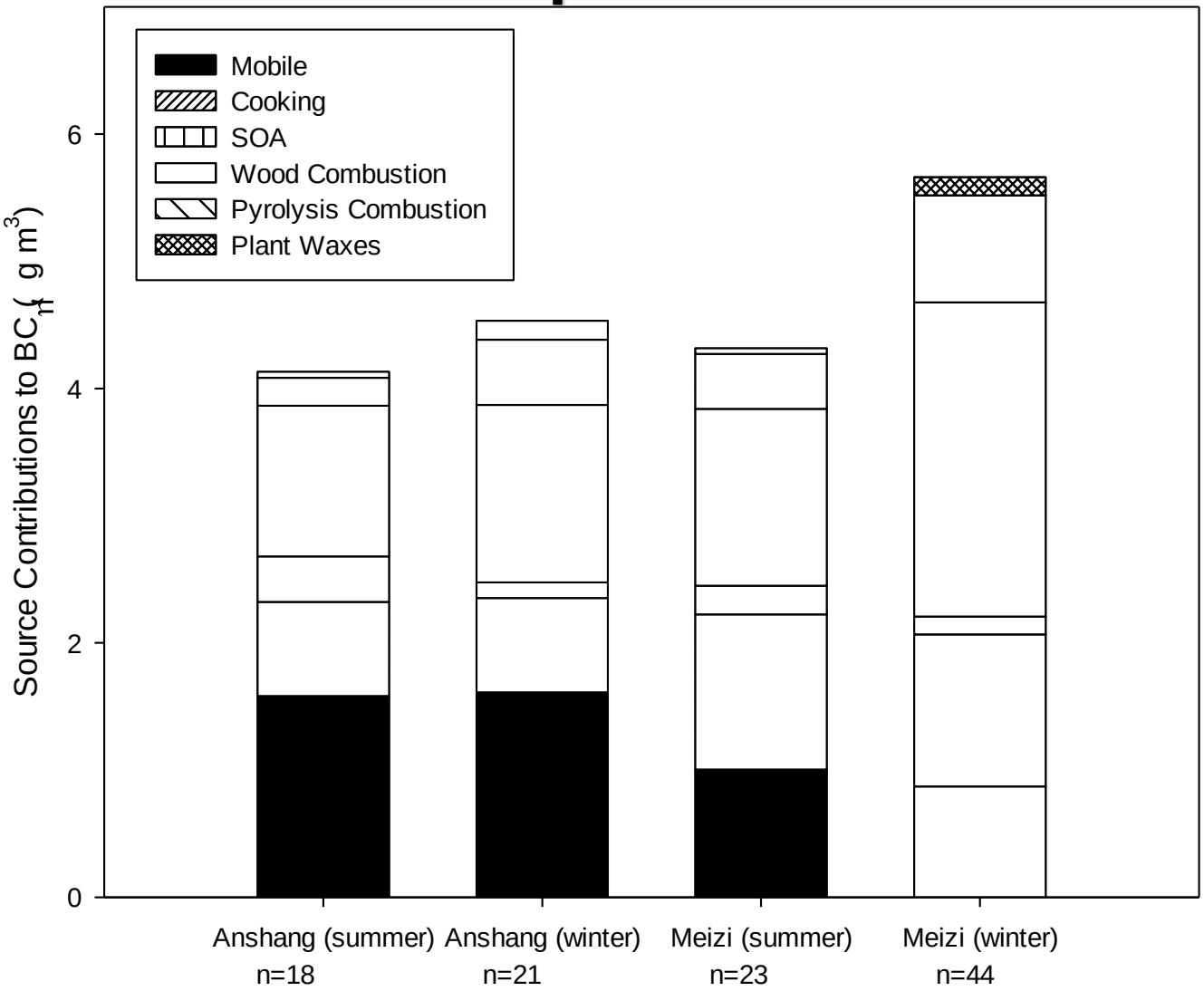


Spatial variation



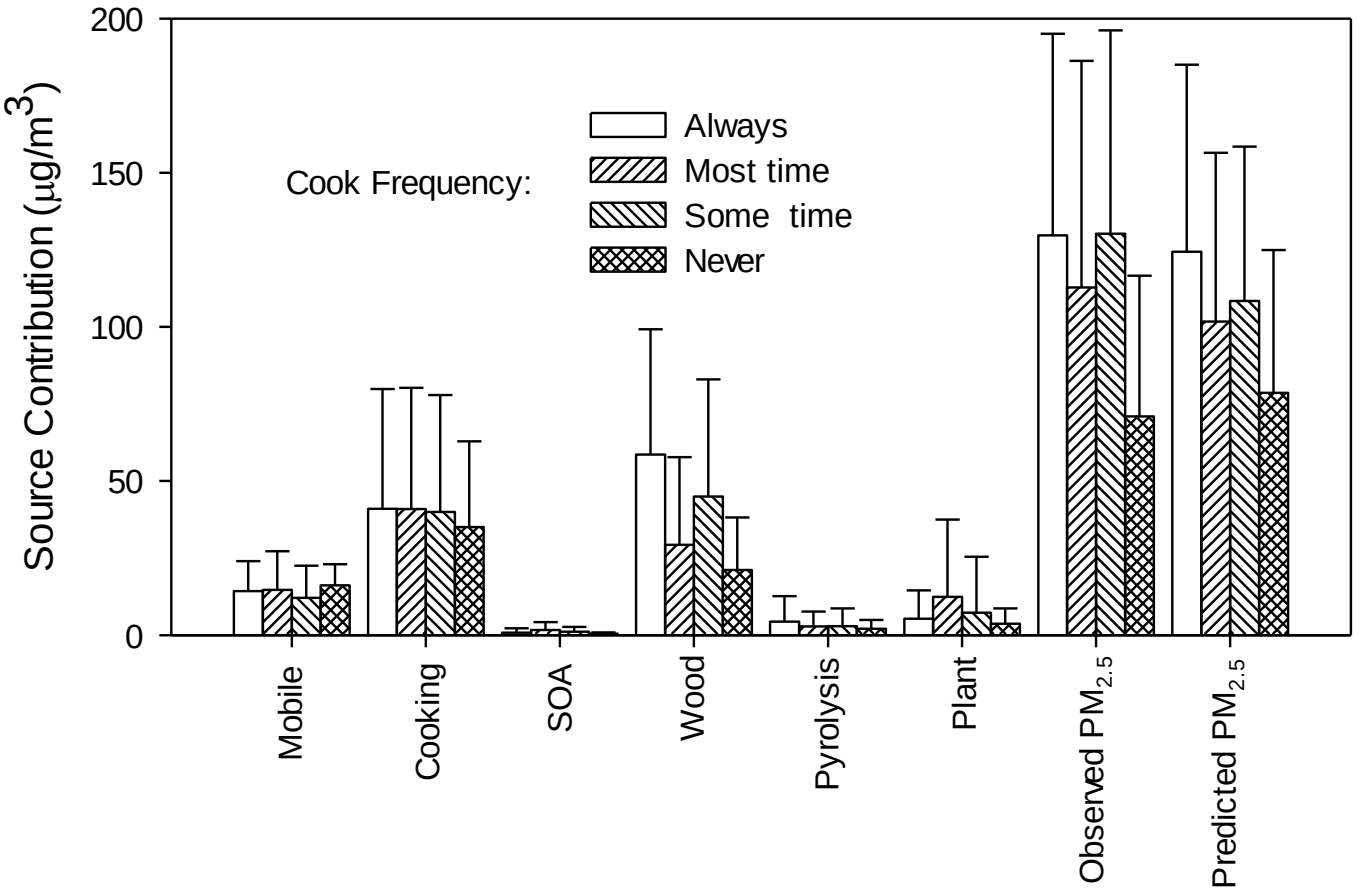
Seasonal variation

Source contributions to BC exposure

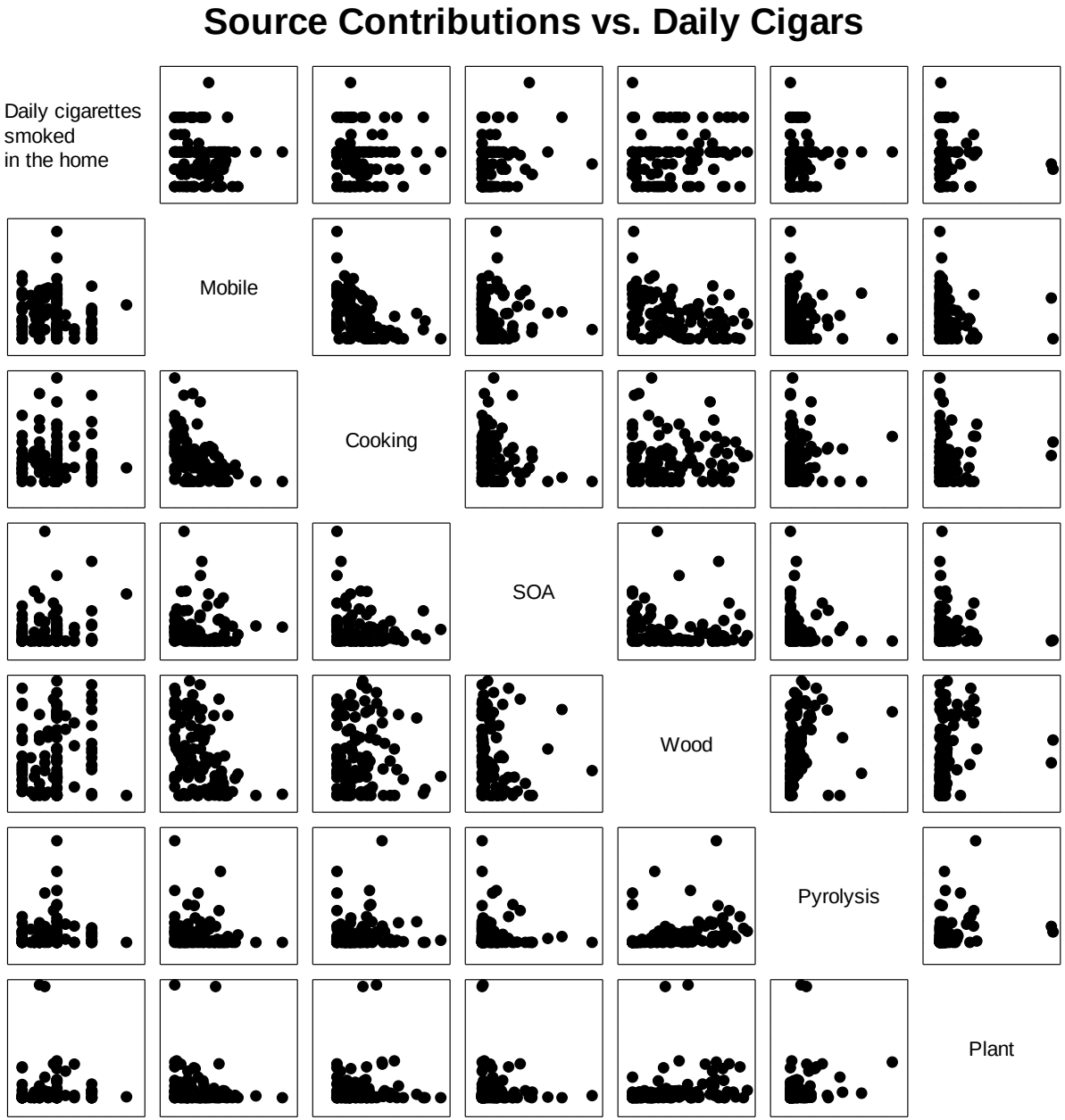


Source contributions vs personal behavior

Cooking frequencies



Daily cigarettes



Distance to roadway

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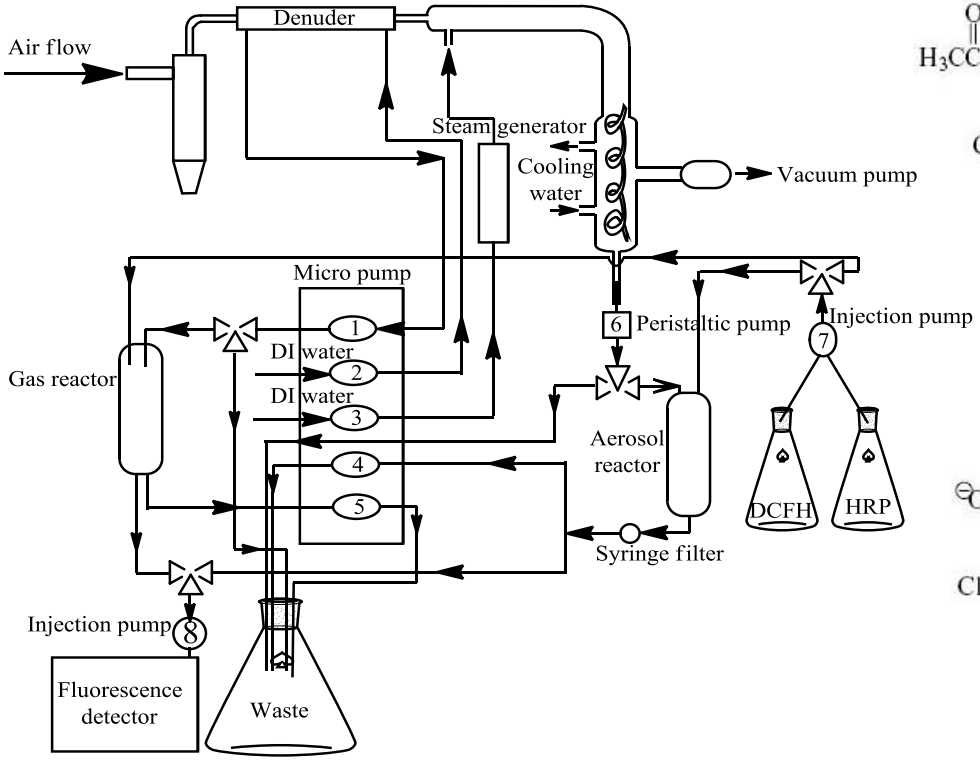
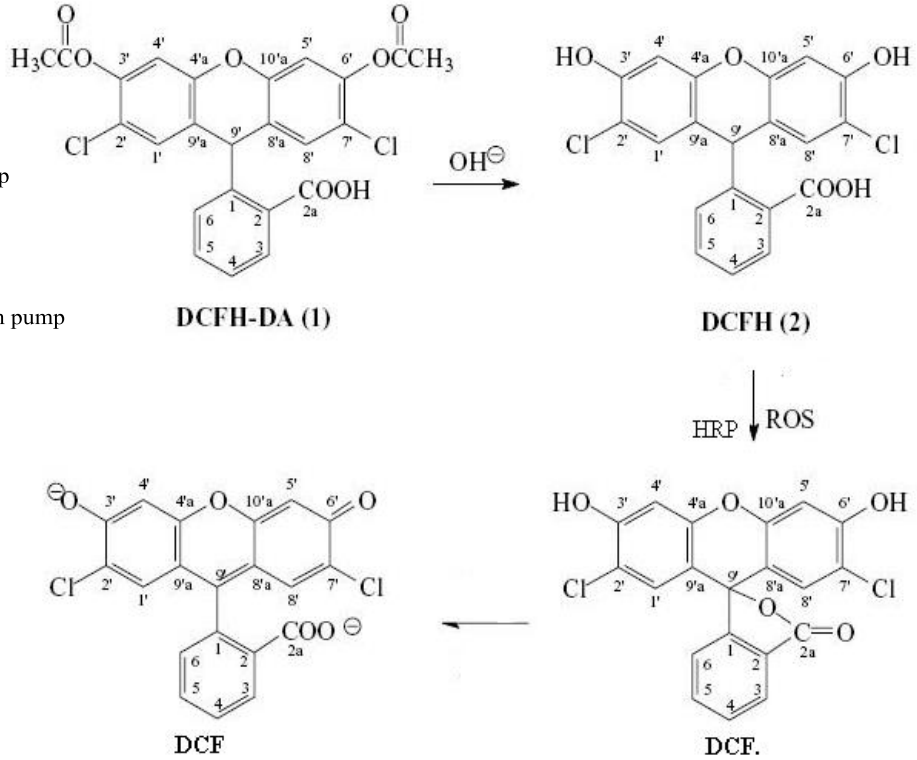
Toxicological measurements

Exogenous ROS:

Online measurement for gas and particle phase ROS



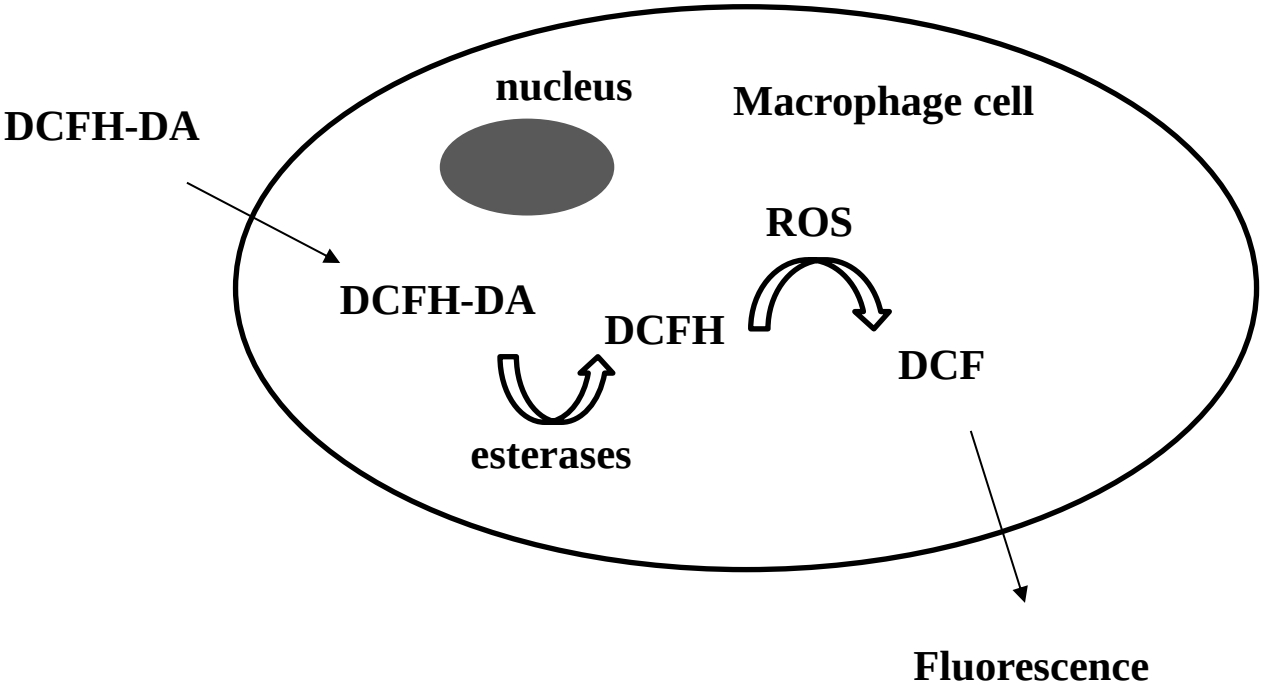


Huang et al, 2016. Development of an automated sampling-analysis system for simultaneous measurement of reactive oxygen species (ROS) in gas and particle phases: GAC-ROS. Atmospheric Environment 134, 18-26

Endogenous ROS:

Biological oxidative of PM

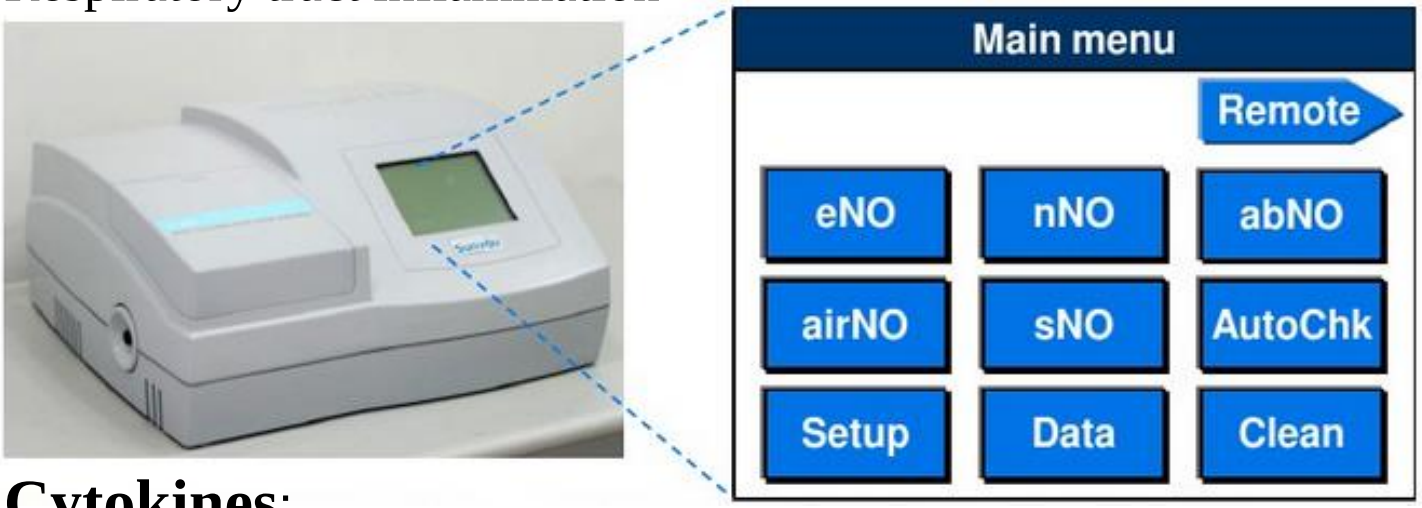
Alveolar Macrophage ROS Assay



Zhang, et al, 2008. Source apportionment of in vitro reactive oxygen species bioassay activity from atmospheric particulate matter. Environ Sci Technol 42(19), 7502-7509

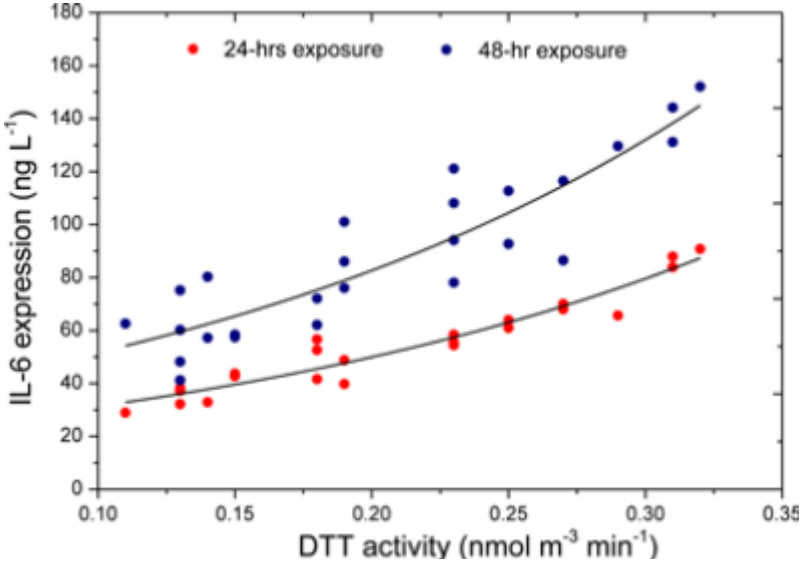
FeNO:

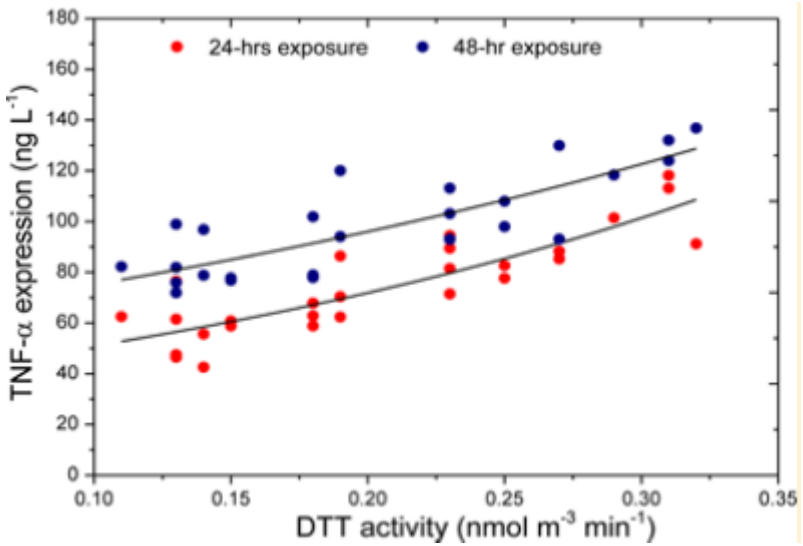
Respiratory tract inflammation



Cytokines:

TNF-α, IL-1, IL-6

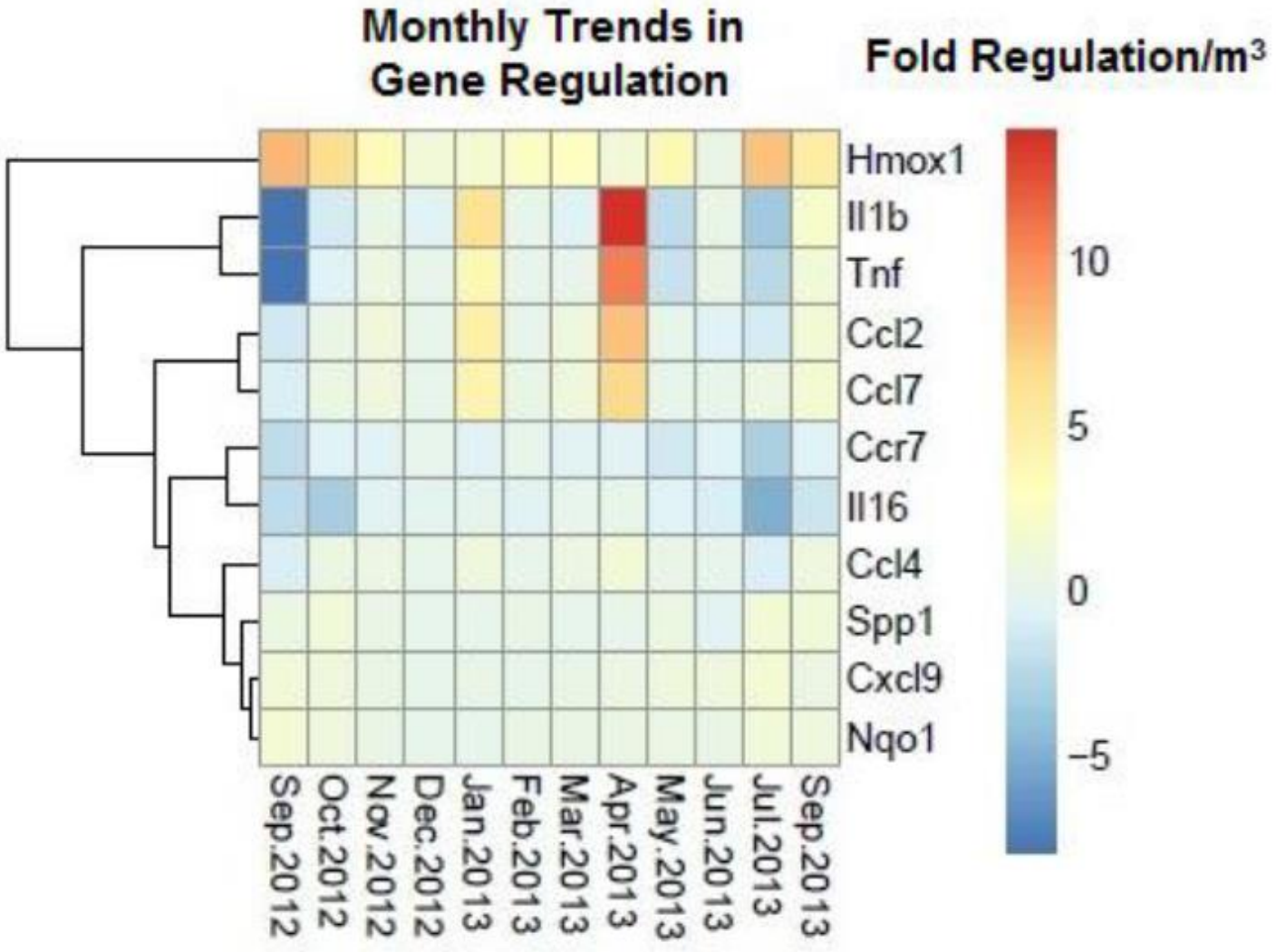




Liu, et al, 2014. Oxidative potential and inflammatory impacts of source apportioned ambient air pollution in Beijing. Environ Sci Technol 48, 12920-12929

Gene expression:

Pro-inflammatory genes



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Implications

- Source apportionments are very different between ambient samples and personal exposure samples;
- It is necessary to keep residential area far away from highway?
- What is the target to better characterize exposures?
  - Source apportionment
  - Toxicity

Summary

- BC has direct relevance as an important environmental risk factor for cardiovascular diseases;
- BC is a pollution indicator in future health studies and in the evaluation of air pollution mitigation programs.

Acknowledgement

- Jill Baumgartner and her team from McGill
- James Schauer and his team from UW-Madison
- UCAS Atmospheric groups


Thanks!