Ion Chromatography Analysis of $PM_{2.5}$ from July 2007-June 2008 DASH and DASH-Spatial Studies

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What is $PM_{2.5}$?

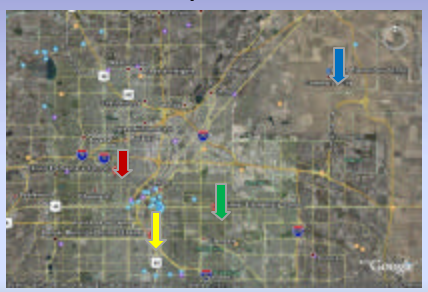
- Fine particles: Diameter of 2.5 microns or less
- Also called aerosol
- From natural and anthropogenic sources
- Can be inorganic ions (my study), organic compounds, or elemental carbon
- Stay in the atmosphere longer
- Penetrate deeper into lungs
- Concern for human health
- Criteria Air Pollutant regulated by EPA:
  - daily limit = 35 $\mu g/m^3$
- Must study $PM_{2.5}$ characteristics in order to pinpoint the problem

DASH Study Background

- Denver Aerosol Sources and Health
- Ongoing 6-year study since 2002
- Quartz and Teflon filters run for 24 hours every day
- Palmer Elementary School
- Cyclone Separator filters in only $PM_{2.5}$
- Flow meter measures volume of air passing through filter
- Weekly blanks do not have air flow
- Every other week duplicate filters

DASH-Spatial Study Background

Four Spatial Sites



Pre-weighs and Post-weighs

- Filters are pre-weighed before going out to the sites
- Filters are post-weighed after they have collected $PM_{2.5}$
- Mass after collection – Mass before collection = Total $PM_{2.5}$ mass collected

Extraction of $PM_{2.5}$ from filters

- Filters immediately go in freezer for long-term storage
- Extraction Procedure:
  - Four weeks DASH data extracted together
  - Two Milli-Q water blanks
  - Put each filter in conical vial using tweezers (this is way more difficult than it sounds!)
  - Pipette 300 µL isopropyl alcohol on the dirty side of each filter
  - Pour 25 mL Milli-Q water into each conical vial
  - Cap vials and place on shaker table for at least 4 hours (usually ~24 hours)

Preparing samples for the IC

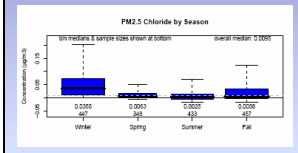
- Pour extracted liquid from each conical vial into each 5mL vial and place on caps
- Push down all caps with plunger, avoid cross-contamination
- Bring samples to the USGS lab
- Pour and cap the calibration standards into 5mL vials
  - 11 anion standards
  - 10 cation standards
- Pour and cap 3 water blanks from the USGS lab and 3 P-standards of known ionic concentrations
- Put all vials in correct order into IC autosampler

Plunging the caps

Running the IC

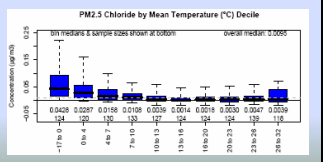
[redacted]

Chloride Trends

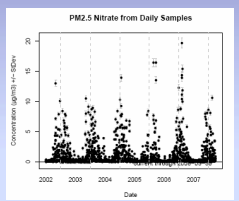


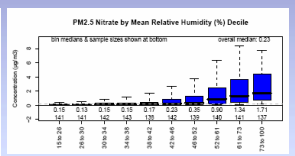
- Chloride is higher at lower temperatures
- Highest concentrations at -17 to 7 degrees Celsius

- Peaks in the winter
- Follows past chloride trends in DASH study
- Slightly higher concentrations at lower wind speed, suggests a local source



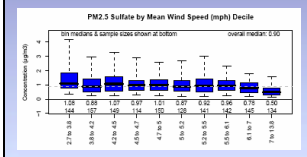
Nitrate Trends

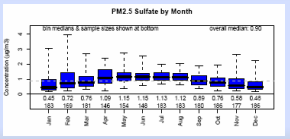


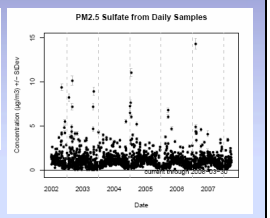


- **Peaks in the winter (very consistent with previous DASH years)**
- **Higher concentrations at higher humidity**
- **Slight correlation to lower wind speeds, suggests a local source**

Sulfate Trends



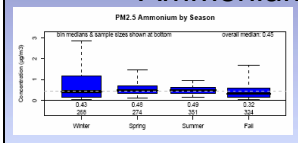


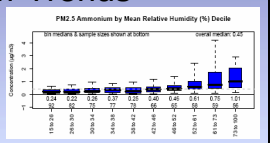


•Peaks in the spring and summer months

•Similar concentrations at all wind speeds, except has a lower concentration at the highest speed, suggests a long-distance source

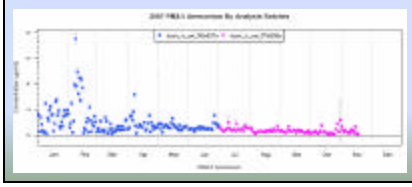
Ammonium Trends





•Similar median concentrations at all seasons

•Concentration increases with increasing humidity



•Limited cation data available

•Data only available until 11/18/2007

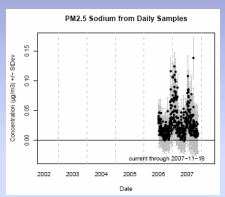
•Winter 2007-2008 is predicted to have a large range of concentrations as in years past

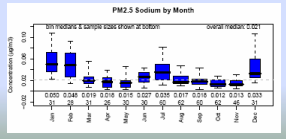
Sodium Trends

•Time series shows large peak in winter and medium peak in summer

•Data only collected since 7/06

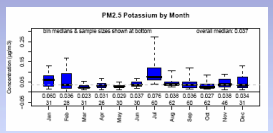
•Limited data





•Highest median concentrations in January, February, July, December, and June in that order

Potassium Trends

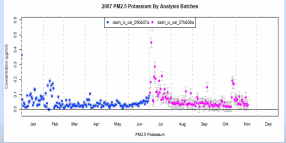


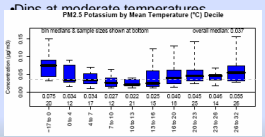
•Peaks in July and a small peak in January

•Limited data

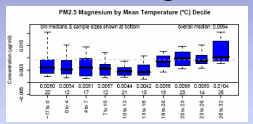
•Median concentration or higher from 16 to 32 degrees Celsius or -17 to 0

•Dips at moderate temperatures





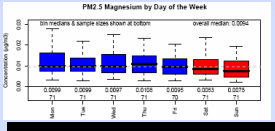
Magnesium Trends

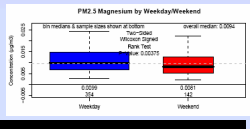


•High concentrations from 16 to 32 degrees Celsius (warm temperatures)

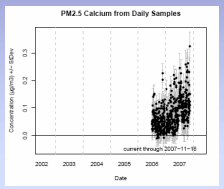
•Still, concentrations in winter and summer are the same, while spring is the peak season

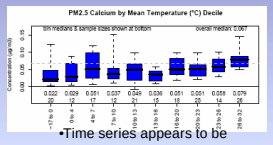
•Limited data



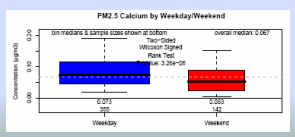


Calcium Trends





•Time series appears to be increasing regardless of season (limited data)



•Highest concentration from 26 to 32 degrees Celsius, summer peak?

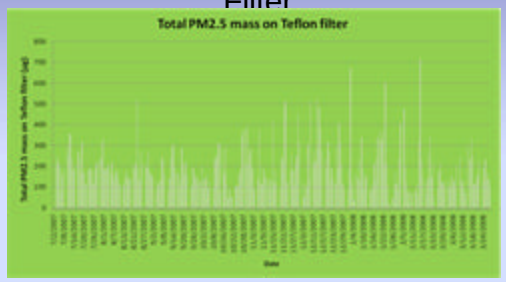
•Weekday/weekend trend

•0.073 µg/m^3 on weekdays

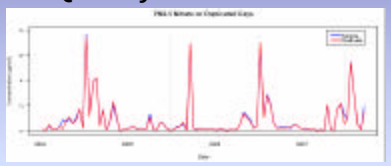
•0.0053 µg/m^3 on weekends

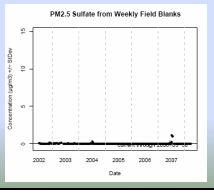
•CARS ARE BAD!!!

Time Series for $PM_{2.5}$ Mass on Filter



Quality Assurance Measures





- Weekly field blanks are analyzed for contamination from DASH procedure
- Every other week duplicate samples are run with Tuesday sample
- If duplicate and sample match up, the samplers are reliable!

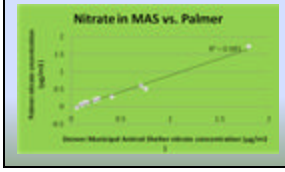
Spatial Nitrate at Four Sites

- Similar concentrations at all four sites means source is long distance
- This contradicts previous local source assumption of nitrate
- Could be both long and short distance sources

Spatial Sulfate at Four Sites

- Concentrations are similar, but Alsup differs at four separate dates
- Suggests long distance source

Comparison between two sites



- Alsup: Commerce City neighborhood with gravel pits, coal-fired power plant, and oil refinery; near I-76; farthest from other sites
- MAS: Industrial area with I-25 nearby
- Palmer and Edison: Residential neighborhoods
- Trendline is not as good for some of Alsup comparisons
- Trendline is very good for all other sites

Summary and Conclusions

- Nitrate peaks in winter and sulfate peaks in summer
- Magnesium and calcium have lower concentrations on weekends, suggests that they come from cars
- Field Blank and duplicate plots show that data is quality
- Nitrate and sulfate concentrations at all four spatial sites are similar on daily basis
  - The pollution is long distance!

Future Work

- Run IC for cations between 11/18/07 through 7/1/08
- Run IC for anions for every day in 4/08, 5/08, and 6/08
- Continue DASH-Spatial sampling for full year trends
- Continue analyzing all cations

Thank you!

- NSF for the REU money
- Dr. Angela Bielefeldt and Amanda Kohler for being the program's advisor and graduate student mentor
- Dr. Mike Hannigan for being a great advisor
- Dr. Steve Dutton for creating everything DASH-related
- Paul Schuster and the USGS lab for letting me use the Ion Chromatograph
- Everyone in the lab that taught me stuff, gave me data, and helped me with my project: John Ortega, Teresa Coons, Dan Williams, Bobby Irmiger, and Andrew Schroeder
- All the REU students for all the good times (i.e. camping trip)