St. Louis - Midwest Supersite Fine Particulate Matter Field Campaign at Reserve, KS

Neil D. Deardorff
Scott A. Duthie
Jay R. Turner

Environmental Engineering Program
Washington University in St. Louis

Jeffery D. Reifschneider

Environmental Department
Sac and Fox Nation of Missouri

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Introduction

• As part of the St. Louis – Midwest Supersite program, a movable measurement platform was instrumented and deployed at two rural locations:
  – Rural southeastern Missouri, approximately 100 km south of St. Louis
  – Rural northeast Kansas, collocated with an IMPROVE protocol site established in Summer 2002

• Measurement Objectives
  – Complement sustained measurements in East St. Louis (IL) by providing urban/rural contrast
  – Explore aerosol climatology in the CENRAP domain to support regional haze program development and implementation

• Measurement Periods
  – August to November, 2001 in Park Hills, MO
  – August to December, 2002 in Reserve, KS
Monitoring Locations

Reserve, KS

CENRAP domain

Park Hills, MO
Measurements Summary - Reserve

• St. Louis - Midwest Supersite movable platform deployed at Reserve, KS, in collaboration with the Sac & Fox Nation of Missouri

• Hourly-average (or finer) data for: meteorology; and PM-2.5 mass, nitrate, sulfate, aethalometer black carbon, and nephelometer light scattering

• Daily 24-hour average data for: PM precursor gases; PM-10 mass; and PM-2.5 mass, ions, carbon, and metals

• Two six-week measurement periods
  – August 24 to October 5, 2002 (continued to October 23)
  – November 18 to December 31, 2002
  – selected semicontinuous monitors operated during the six-week interim period
Features of this Presentation

• Emphasis on Reserve, KS measurements…
  – Anatomy of a regional sulfate event
  – Potential evidence for long-range transport of smoke
  – Field application of anhydrous ammonia
• Brief results from the Park Hills, MO measurements…
  – Comparisons of components coupled and uncoupled with St. Louis data

Anatomy of a Regional Sulfate Event

• Four tools to demonstrate the event structure…
  – Semicontinuous sulfate measurements in Reserve and St. Louis
  – daily 24-hour integrated sulfate in Reserve and St. Louis
  – 1/3 day 24-hour integrated sulfate at the IMPROVE network sites
  – Naval Research Laboratory (NRL) model predictions
Regional IMPROVE Data and Air Mass Back Trajectories

Air mass back trajectories from NOAA/ARL HYSPLIT model
Semicontinuous Sulfate in Reserve

- Harvard School of Public Health (HSPH) sulfate method
  - 54% conversion efficiency during this deployment as determined by comparisons to daily 24-hour integrated filter sulfate by the Harvard-EPA Annular Denuder System (HEADS)
PM-2.5 Sulfate Event

Top: Predicted sulfate from the Naval Research Laboratory (NRL) NAAPS model.

Bottom: Sulfate measured at an urban site (St. Louis) and rural site (Reserve).

On August 28 the northwestern edge of the high sulfate domain includes St. Louis but not Reserve, while on August 31 the high sulfate domain extends west to Reserve.
Supersite versus IMPROVE Comparisons
PM-2.5 Sulfate: August 24 – November 30, 2002

- Excellent agreement between HEADS and IMPROVE sulfate data
- Intercept statistically indistinguishable from zero at 95% CL
- Slope statistically indistinguishable from unity at 95% CL
Supersite versus IMPROVE Comparisons PM-2.5 Nitrate: August 24 – November 30, 2002

- Excellent agreement between HEADS and IMPROVE nitrate data (note scales are factor of two smaller than sulfate scatter plot)
- Intercept statistically indistinguishable from zero at 95% CL
- Slope statistically indistinguishable from unity at 95% CL

[IMPROVE] = (1.00 +/- 0.09) x [HEADS]

$R^2 = 0.934$

$N = 19$ (August - November 2002)

colocated precision = 0.21 $\mu g/m^3$
PM-2.5 Sulfate and Associated Ammonium: August 28 – October 9, 2002 (Period #1)

The graph shows the concentration of PM-2.5 sulfate and the moles of ammonium per mole of sulfate (with nitrate correction). The y-axis represents the PM-2.5 Sulfate concentration in μg/m³, and the x-axis represents the dates from 08/28/02 to 10/02/02. The data indicates fluctuations in sulfate concentration and the ratio of ammonium to sulfate over the specified period.
PM-2.5 Sulfate and Associated Ammonium: November 18 – December 31, 2002 (Period #2)
Long-Range Transport of Smoke: Do Fires Show up in the Reserve data?

- Instances of coupled high concentrations of aethalometer black carbon (BC) and sulfate observed
- During such periods, air masses back trajectories originate in the southeastern U.S. pass and pass nominally through Arkansas before arriving in Reserve, KS.
  - NRL model qualitatively consistent with these observations when fires are reported in MODIS (database from which model is developed)
- Large number of fires in Arkansas during the early part of September from Arkansas Fire Reports which are not reported in MODIS
  - Satellite imagery detects possible smoke haze
Carbon-Sulfate Coupling

Sulfate Concentration ($\mu$g/m$^3$)

Black Carbon Concentration ($\mu$g/m$^3$)

Sept. 5: Coupled
Sept. 10: Coupled
Sept. 11: Decoupled

HSPH Sulfate
Aethalometer Black Carbon

0 0.5 1 1.5 2
0 5 10 15 20
9/4/02 9/5/02 9/6/02 9/7/02 9/8/02 9/9/02 9/10/02 9/11/02 9/12/02 9/13/02 9/14/02 9/15/02
NRL Model Predictions

- On September 5 trajectories and prediction maps qualitatively show a relation to transport from the Southeast.

Air mass back trajectory for noon CST on September 5
Carbon-Sulfate Coupling

Sulfate Concentration (µg/m³)

Black Carbon Concentration (µg/m³)

Sept. 5: Coupled
Sept. 10: Coupled
Sept. 11: Decoupled

HSPH Sulfate
Aethalometer Black Carbon

Sept. 15: Coupled
Air Mass Back Trajectories and Carbon-Sulfate Coupling

Sept. 10: CARBON & SULFATE COUPLED

Sept. 11: CARBON & SULFATE DECOUPLED
• Satellite imagery shows possible smoke haze
• Large number of fires in Arkansas during this period according to Fire Reports from the State of Arkansas (need to check other states)
Ambient Ammonia

- Anhydrous ammonia application observed in the late fall / early winter, coinciding with large spikes in ammonia at the monitoring site (daily 24-hour integrated samples from the Harvard-EPA Annular Denuder System, HEADS)

Field Operator noted on November 18 that anhydrous ammonia application occurred at a field north of the site.
Urban/Rural Contrast Measurements

- Deployment at Park Hills, MO, which is approximately sixty miles south of the City of St. Louis and the East St. Louis, IL, St. Louis – Midwest Supersite core monitoring location
- Gaseous species and particulate matter components exhibit varying degrees of coupling, ranging from highly coupled for sulfate to highly decoupled for elemental carbon and gaseous ammonia
Future Plans

• Submit validated data to VIEWS
• Further investigate observed features observed in the data towards developing a conceptual model for aerosol climatology in Northeast Kansas to support regional haze planning
• Execute and report out on the data analysis plan elements

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