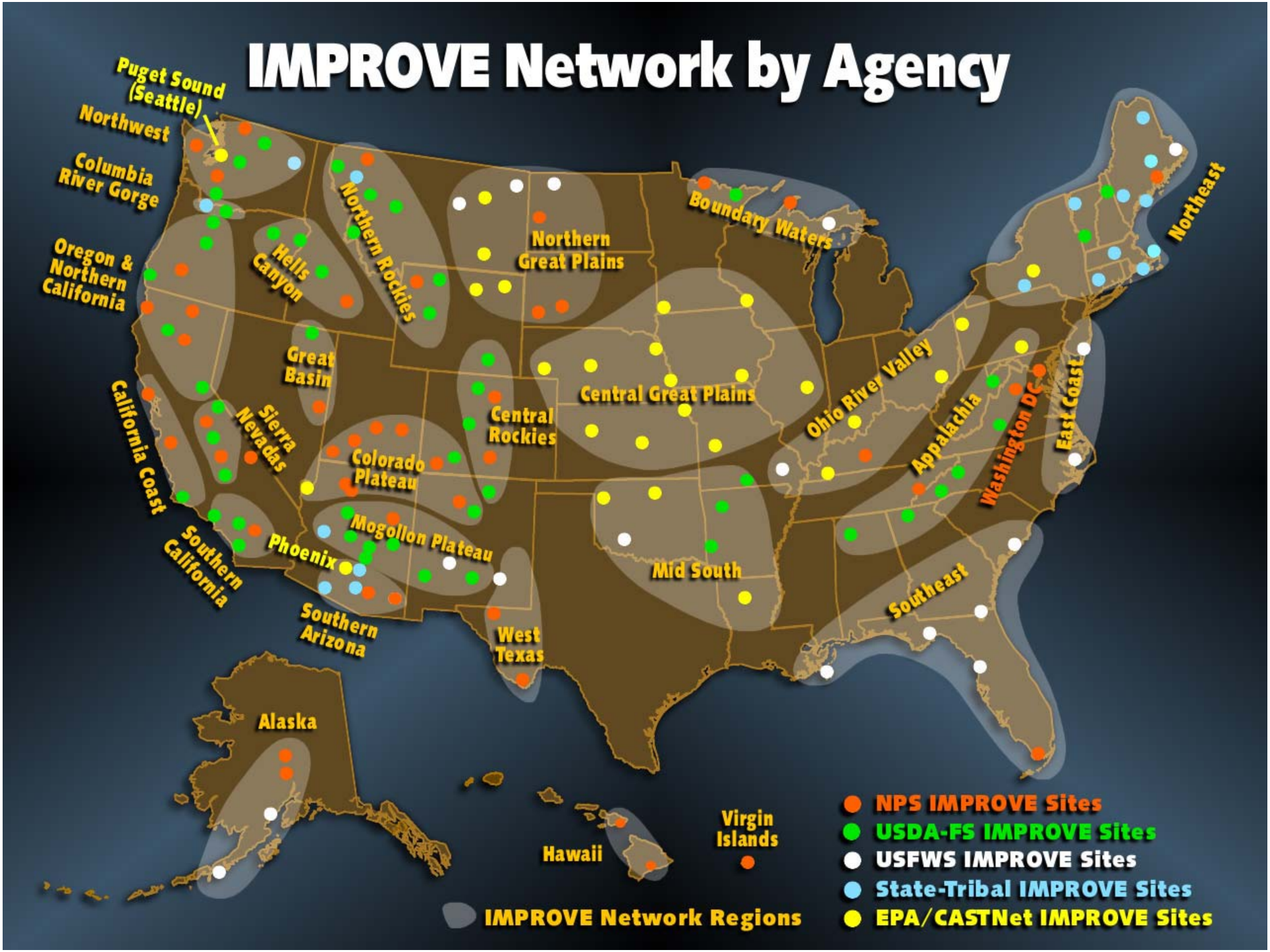
IMPROVE - Benefits of a National Monitoring Network

Presented at the 2006 National Air Monitoring Conference
by Marc Pitchford, IMPROVE Steering Committee Chair

On behalf of numerous dedicated site operators; and field, laboratory and data technicians and scientists without whom there would be no benefits.

IMPROVE Aerosol Speciation Monitoring Network

- Interagency Monitoring of Protected Visual Environments (IMPROVE)
- 110 IMPROVE sites representative of 155 of the 156 visibility-protected federal class I area (national parks and wilderness areas), managed by a 10 member federal/state steering committee
- ~50 IMPROVE Protocol sites operated identically to the 110 sites, but individually sponsored by federal, state & tribal organizations
- One day in three 24-hour duration $PM_{2.5}$ and PM_{10} samples analyzed for mass and $PM_{2.5}$ for major species and trace elements
- http://vista.cira.colostate.edu/improve/


IMPROVE Network by Agency
Puget Sound (Seattle)
Northwest
Columbia River Gorge
Oregon & Northern California
Hells Canyon
Northern Rockies
Northern Great Plains
Boundary Waters
Northeast
Great Basin
Sierra Nevadas
California Coast
Central Rockies
Central Great Plains
Ohio River Valley
Appalachia
Washington DC
East Coast
Colorado Plateau
Mogollon Plateau
Phoenix
Southern California
Southern Arizona
West Texas
Mid South
Southeast
Alaska
Hawaii
Virgin Islands
IMPROVE Network Regions
NPS IMPROVE Sites
USDA-FS IMPROVE Sites
USFWS IMPROVE Sites
State-Tribal IMPROVE Sites
EPA/CASTNet IMPROVE Sites

National Monitoring Network Benefits

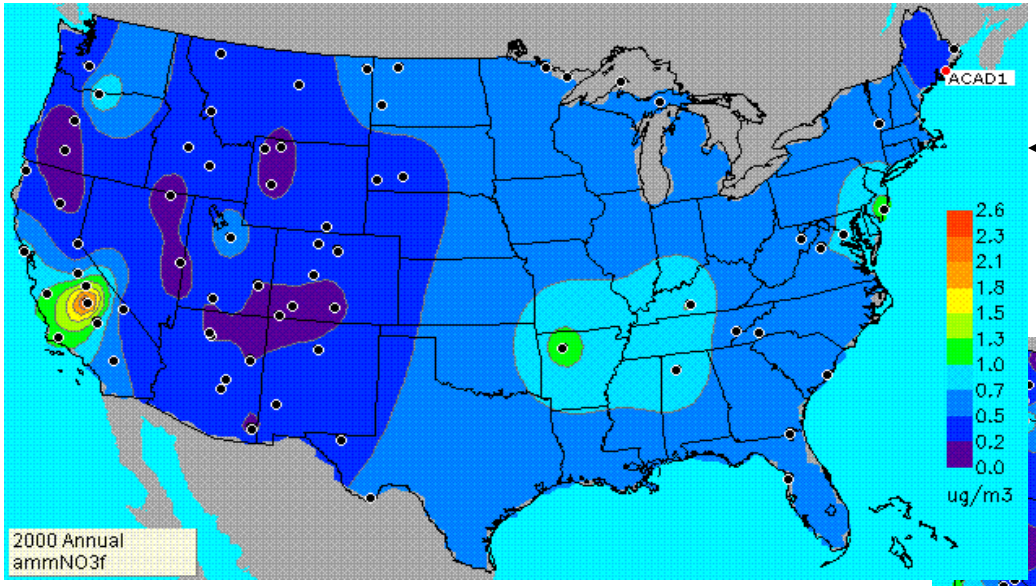
Five Generic Benefits of IMPROVE

1. Ability to track large spatial and long-term temporal trends
2. Provides context to smaller scale, short-term air quality studies
3. Consistent data sets for use in regional and continental-scale source and receptor modeling
4. Infrastructure to investigate and refine monitoring methods and data quality
5. Consistent and accessible ambient data and methods documentation

Examples of Each to Follow

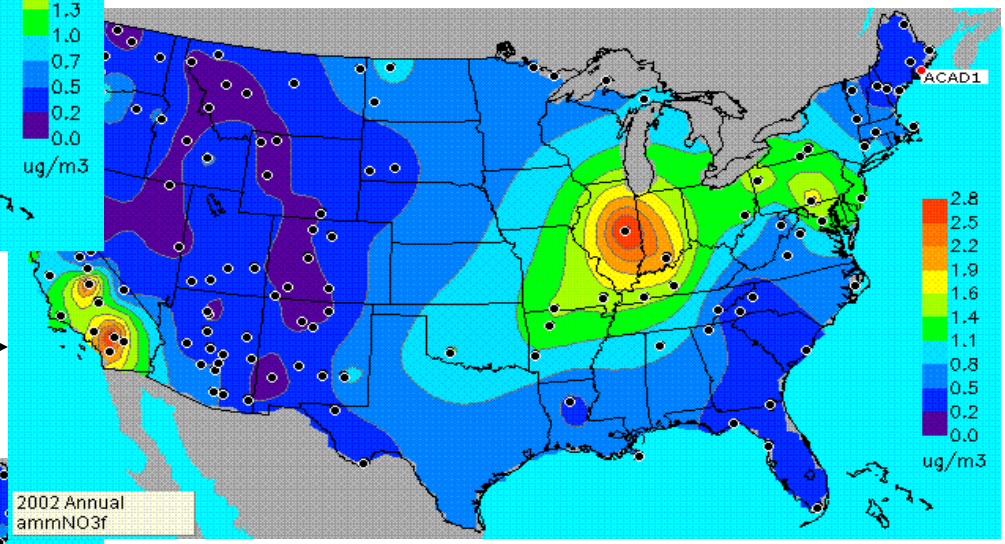
1. Spatial & Temporal Trends

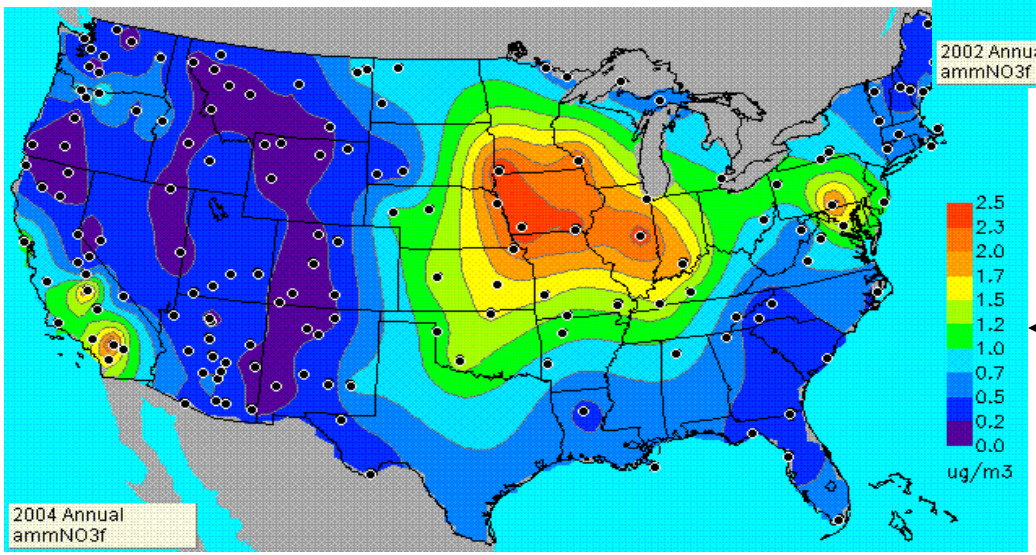
Midwestern Nitrate Bulge - Apparent only as Network Expands



Nitrate is principally seen as a rural Southern California phenomena with the IMPROVE network in 2000

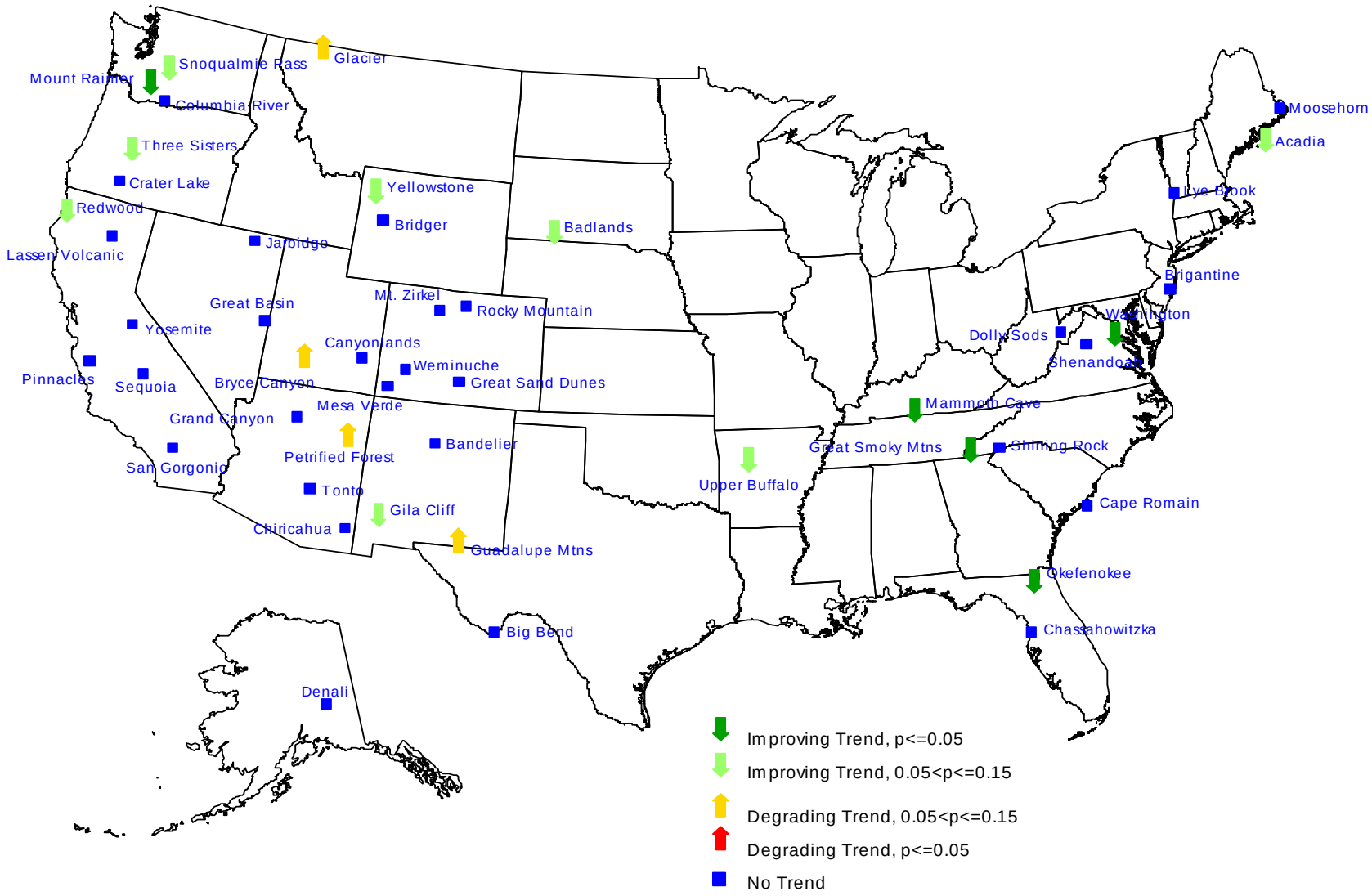
New sites in the center of the country show a bulge centered on Illinois, 2002





Additional Midwestern sites in 2004 show the full extent of the rural nitrate bulge which dominates winter $PM_{2.5}$ and seems to coincide with the region of high ammonia emissions

Trends in Haze Index (Deciview) on Haziest Days, 1995-2004



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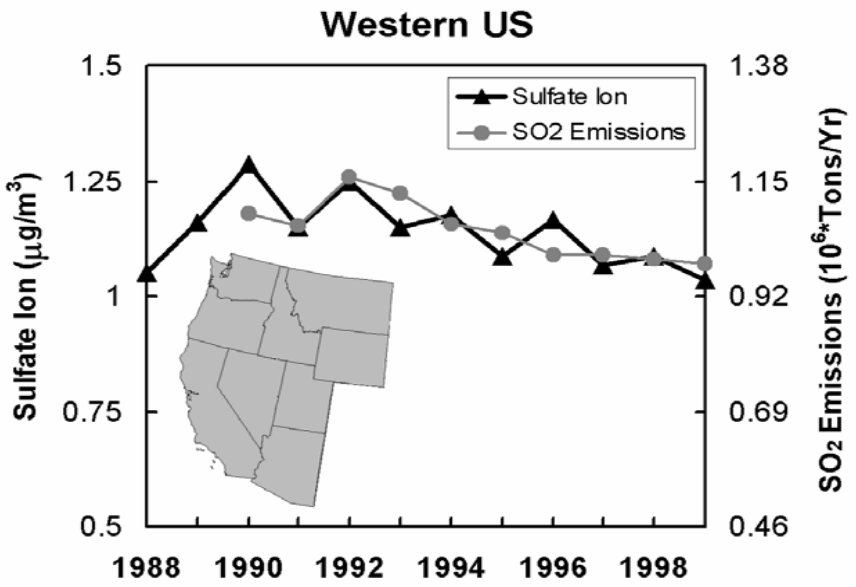
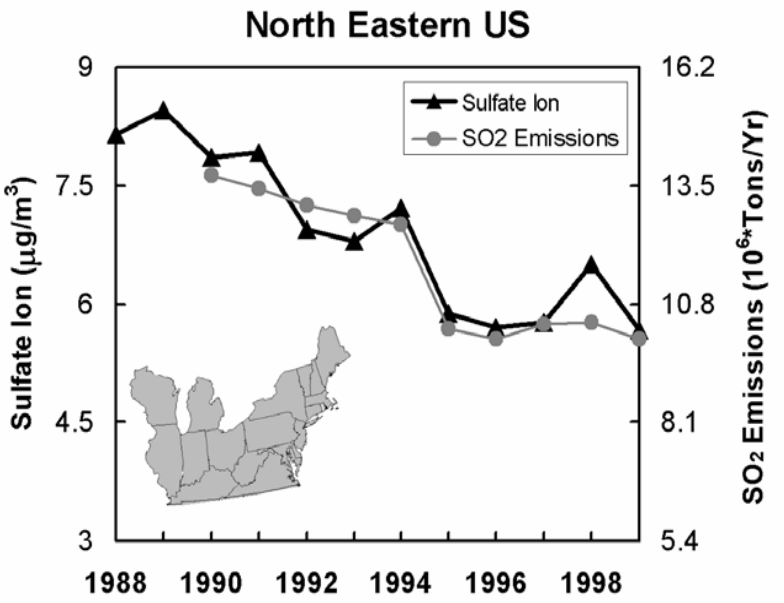
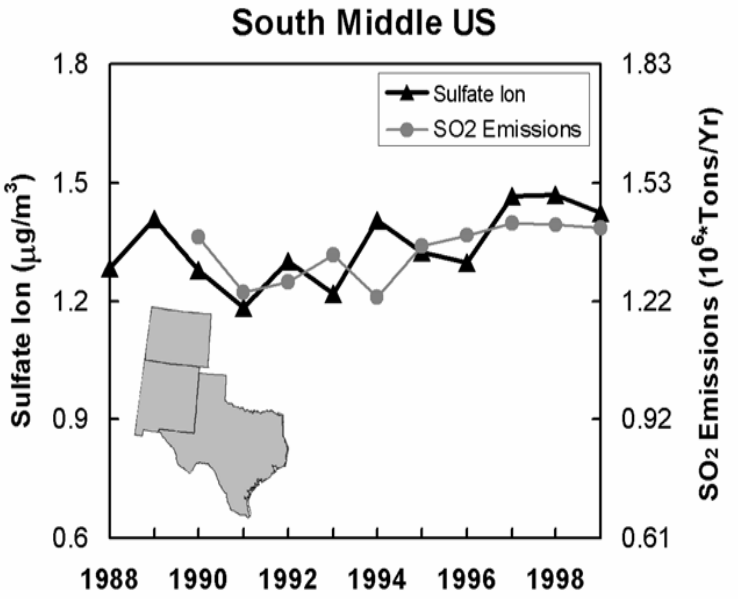
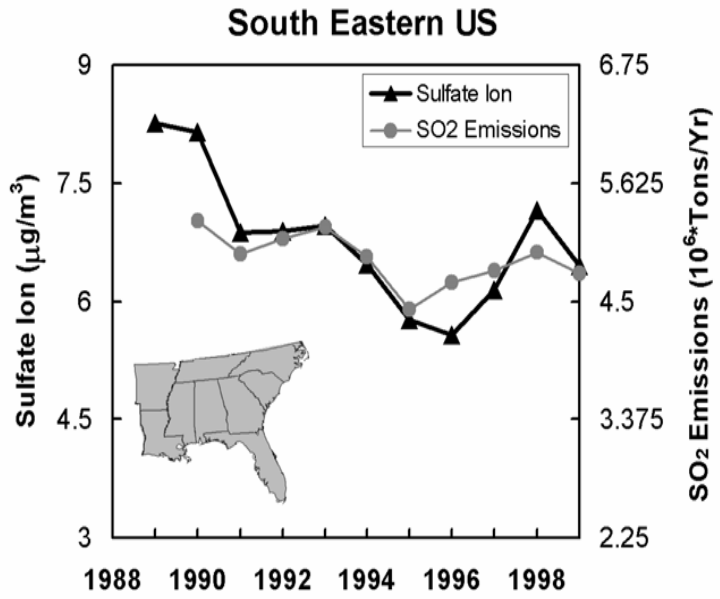
Correspondence Between Regional Aerosol Sulfate and SO_2 Emissions Trends



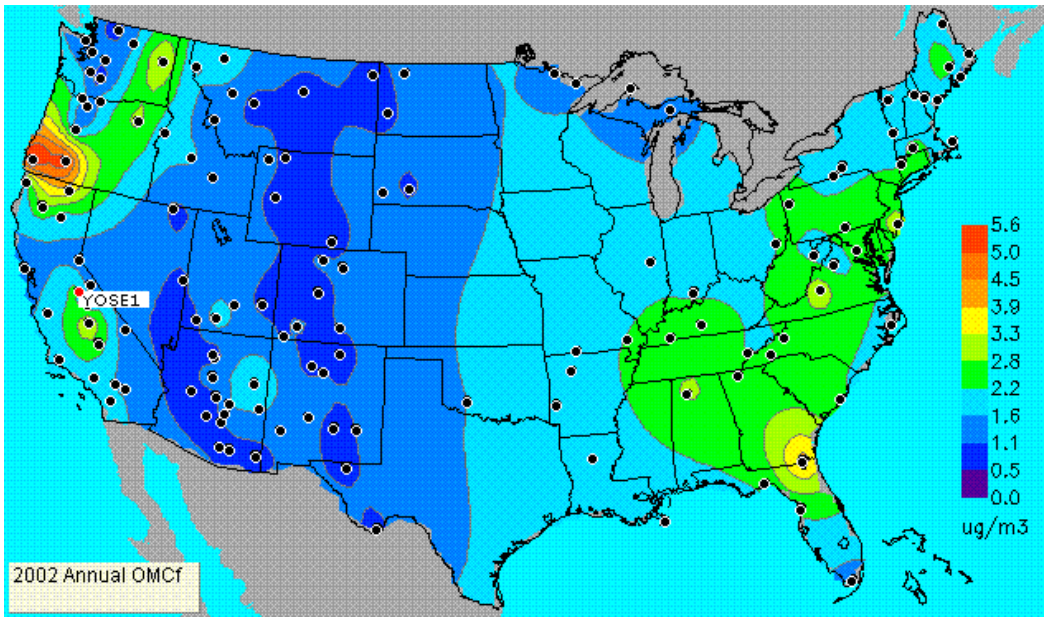




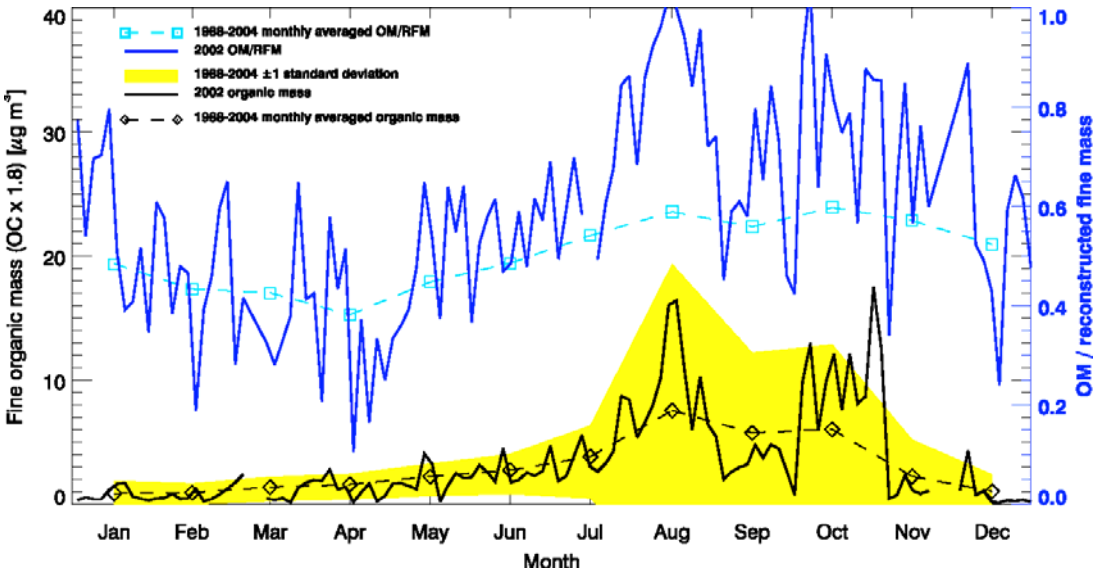


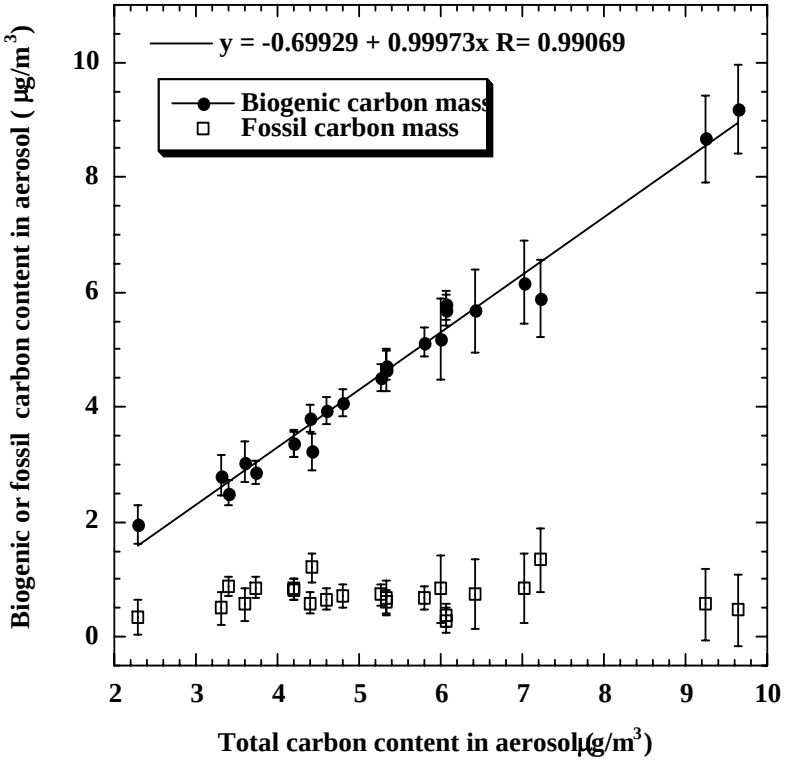
2. Spatial & Temporal Context

Yosemite Aerosol Characterization Study



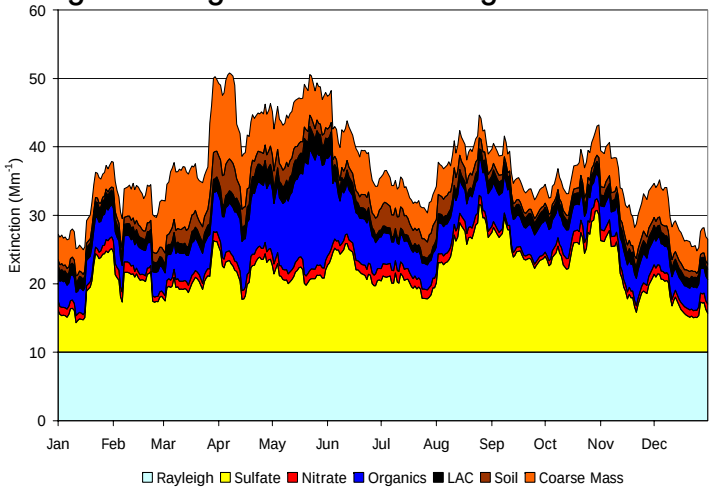
- What causes the high organics at sites on the west slopes of the Sierra Nevada Mountains?
- A special study conducted during the period of historic high organic mass at Yosemite shows that the carbon is mostly recent, not fossil.



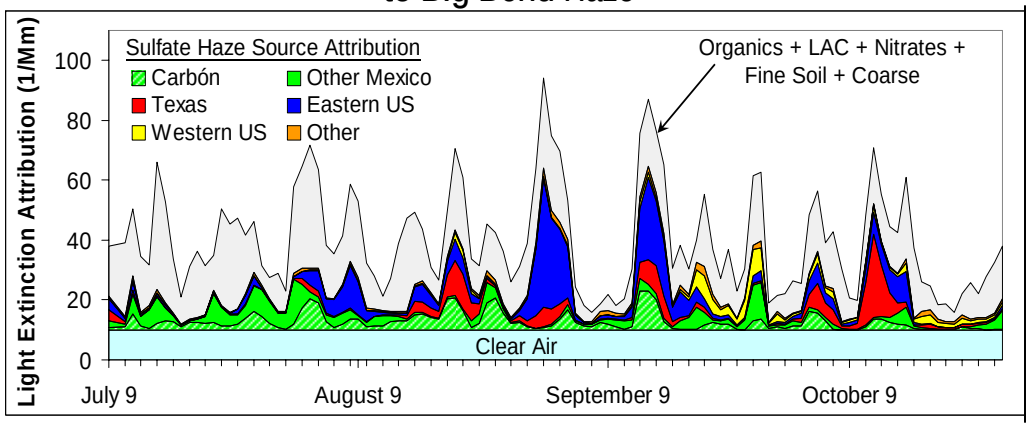


Big Bend National Park Sulfur Haze Attribution (BRAVO) Study

Big Bend Light Extinction Budget – 1998 to 2002

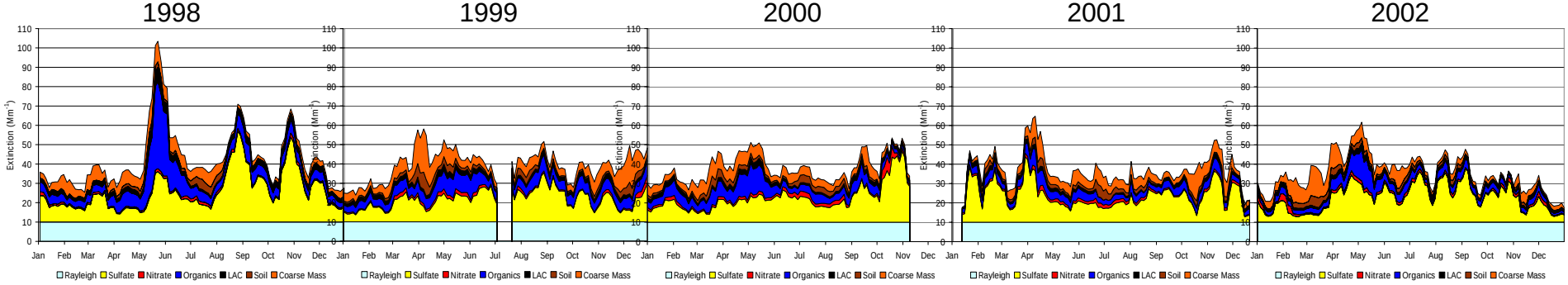


"BRAVO Estimate" – Daily Sulfate Attribution to Big Bend Haze



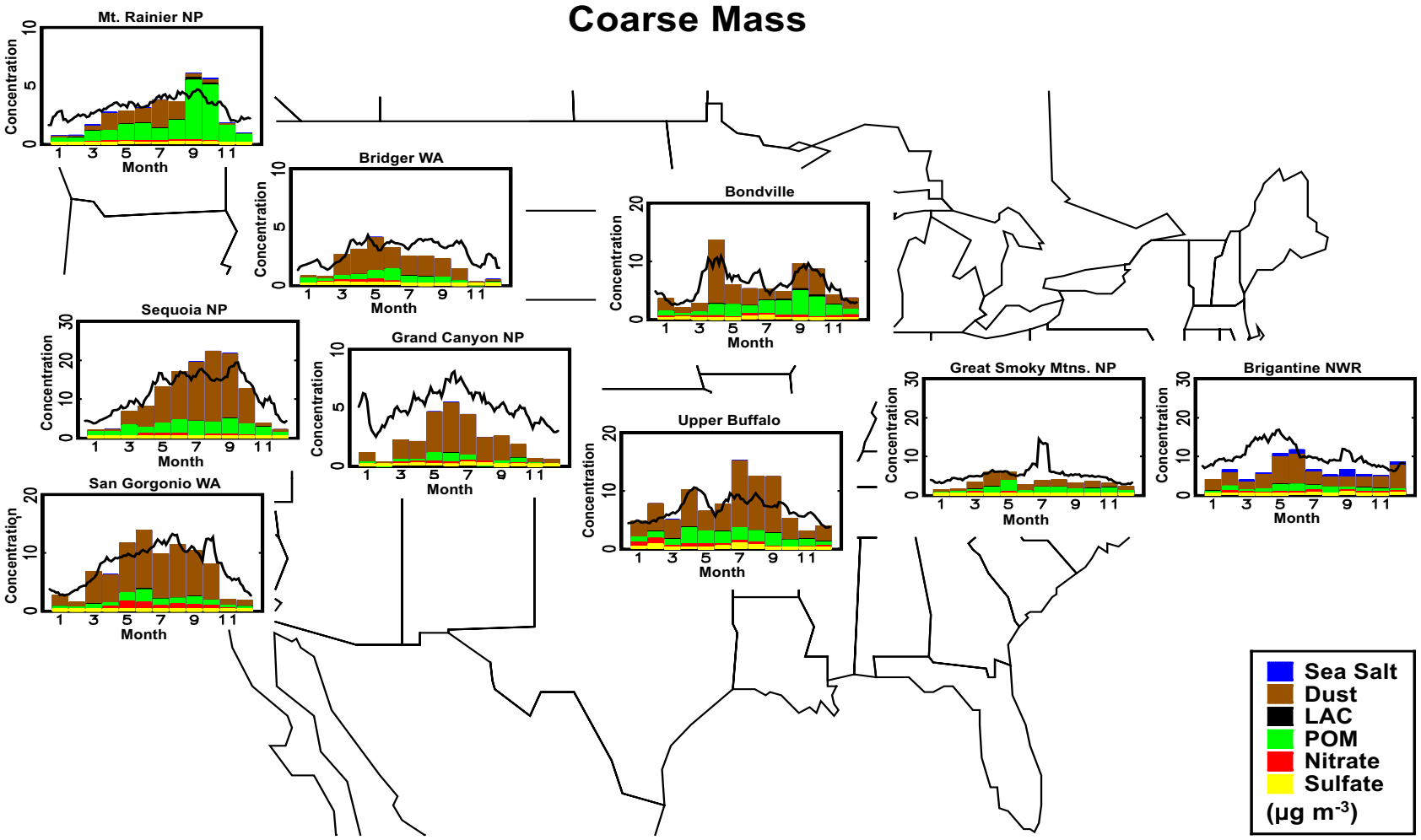
Multiyear composite data was used to help select the study period (July through October.

Attribution modeling showed that some source regions contribute in short term episodes causing large haze peaks



Data from individual years demonstrates a large degree of interannual variability used to provide long-term context for this four month study.

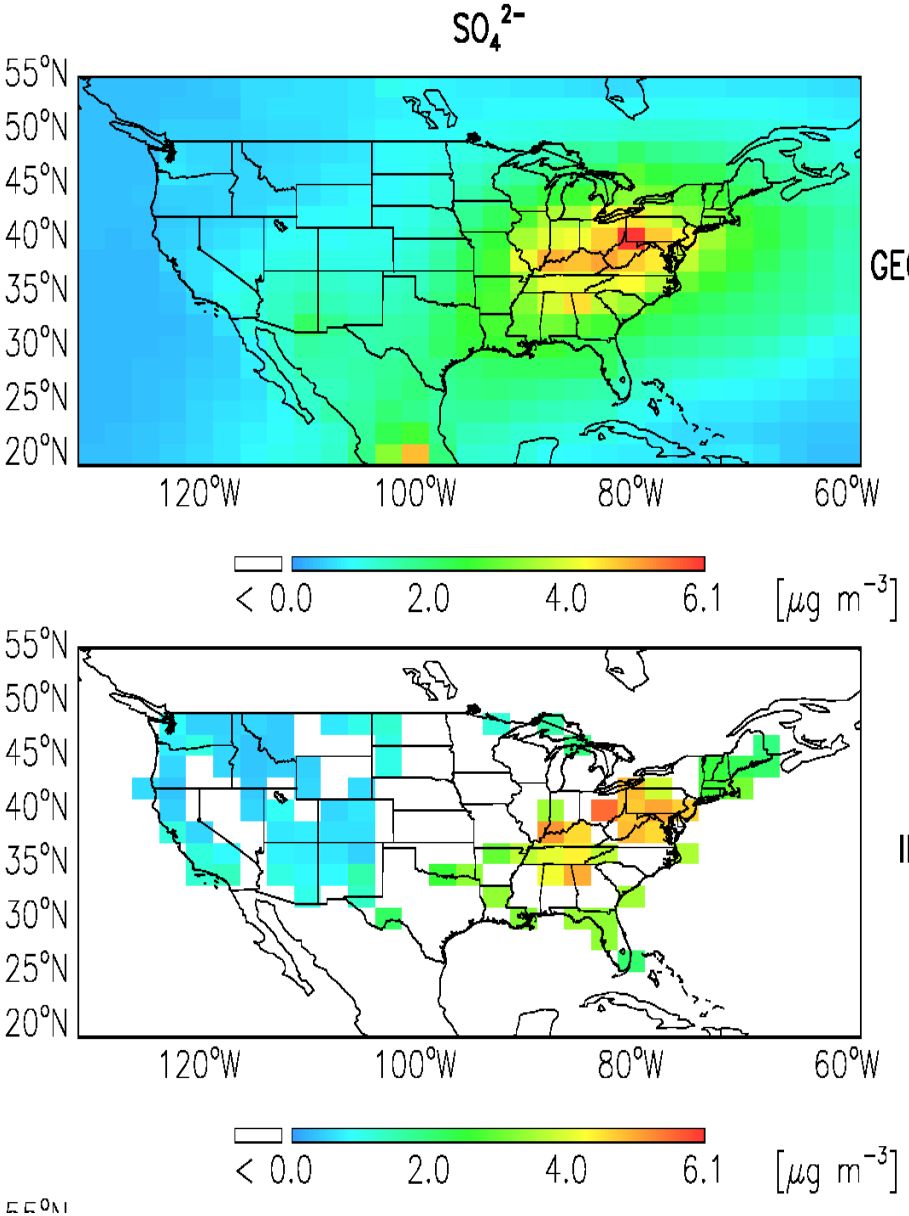
One Year Special Study of Coarse Particle Composition by Deploying IMPROVE Comparable PM10 Speciation Sampling at Nine IMPROVE Sites



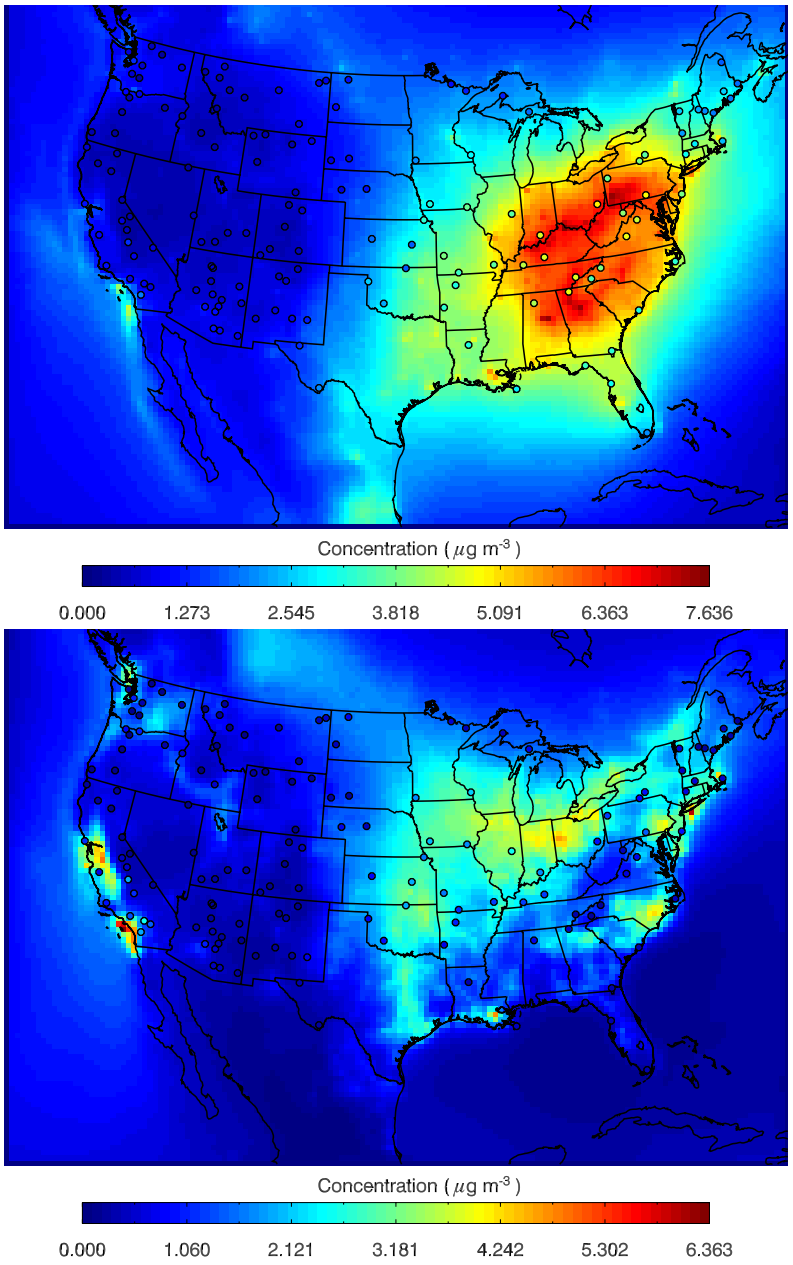
A map of stacked bar charts showing the coarse mass concentration of each species at each of the nine locations at which measurements were made. The continuous lines are running averages of the data collected historically at each monitoring site.

3. Source & Receptor Modeling Uses

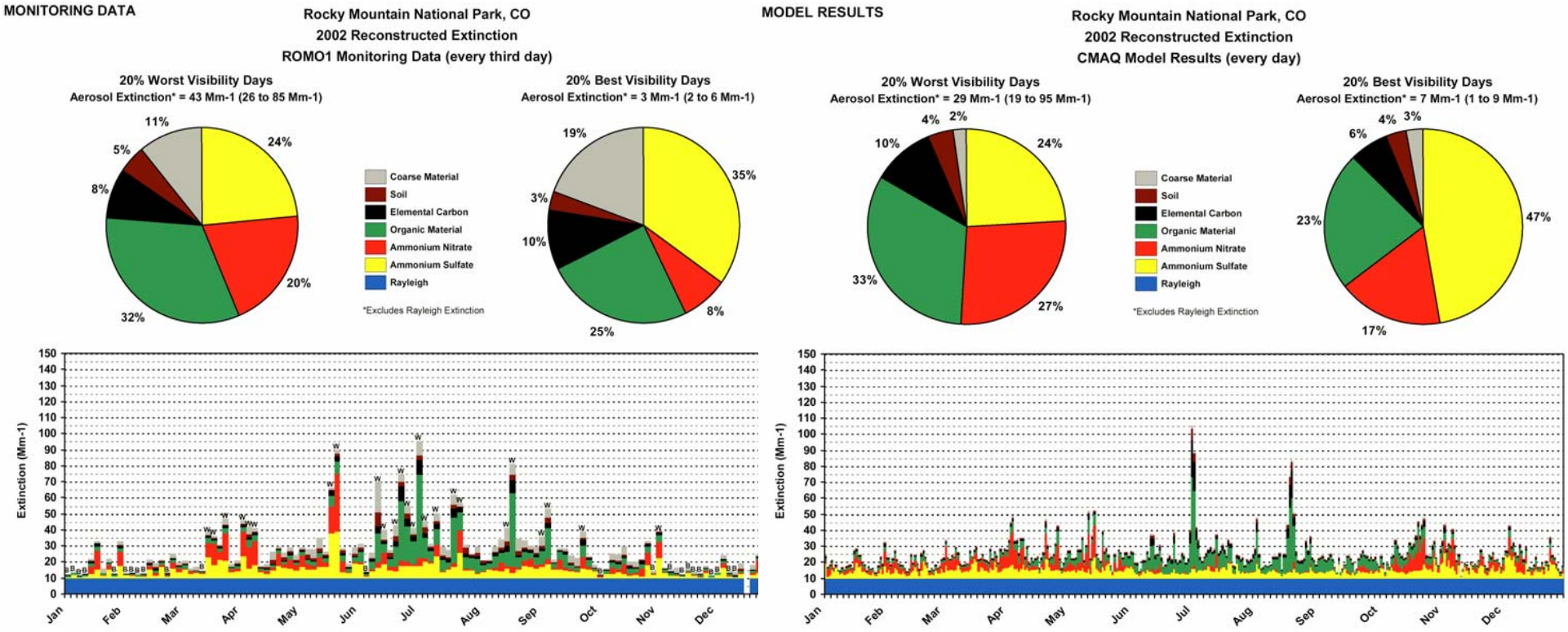
ANNUAL MEAN SULFATE (2001): GEOS-CHEM vs. IMPROVE (141 sites)



CAMx vs. IMPROVE (2002) Sulfate (top) & Nitrate (bottom)

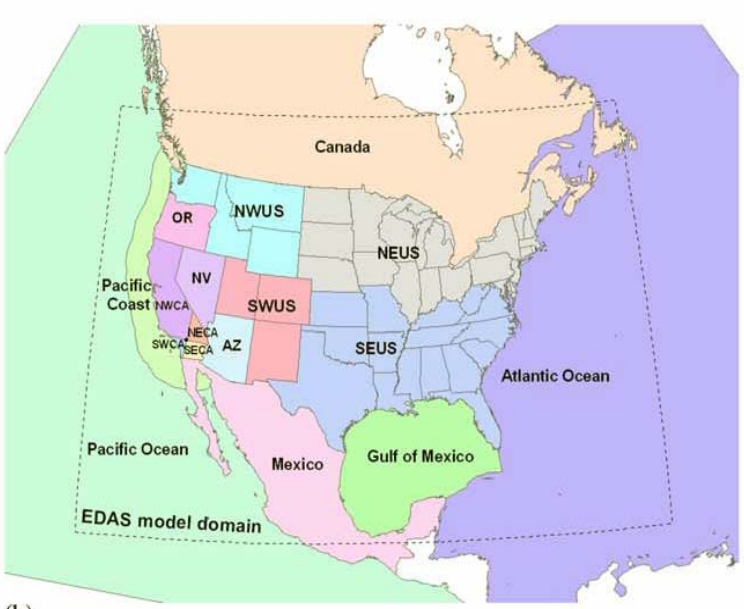


Observed versus Modeled Reconstructed Light Extinction at Rocky Mountain National Park



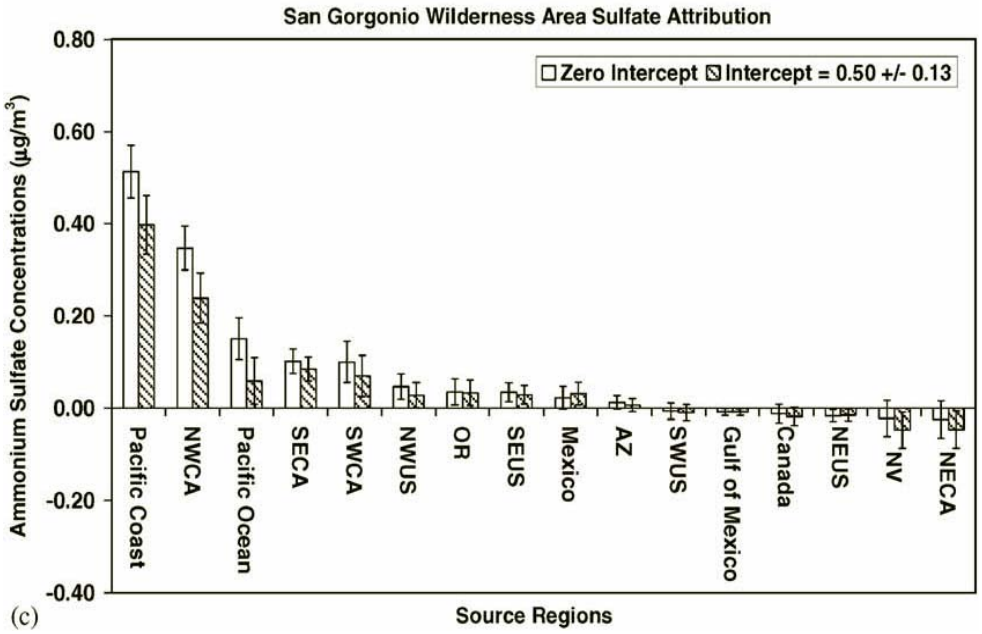
- Comparisons of IMPROVE measured versus CMAQ simulated haze by aerosol component are used to demonstrate model performance
- RPOs conducted similar assessments for all rural IMPROVE monitoring sites

Back-Trajectory Regression Analysis

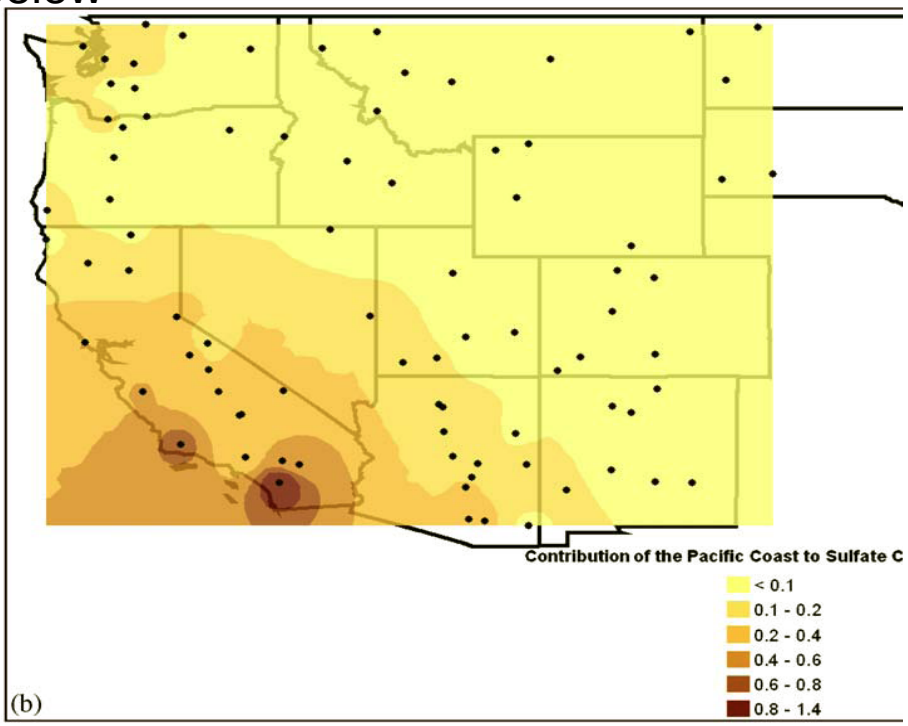


(b)

- Domain is divided into source regions
- Linear regression of trajectory residence time in each source (independent variables) is used to estimate their contributions to particulate sulfur concentration (dependent variable) at each site (San Gorgonio results shown)
- Contours of sulfate contributed at all the western sites by the Pacific Coastal source region is mapped below



(c)



(b)

4. Investigate & Refine Monitoring Methods

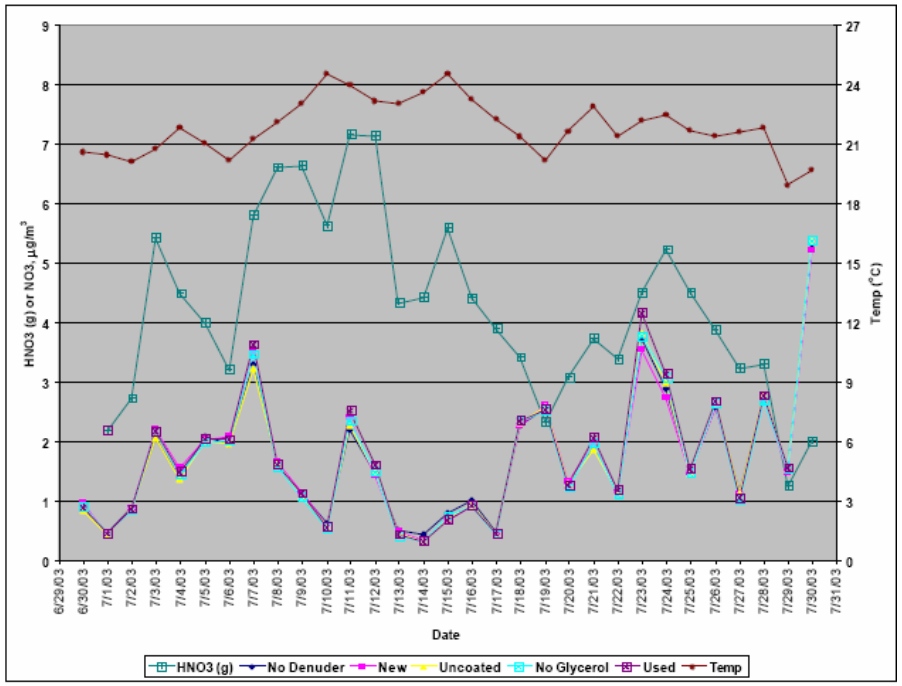
- Mud daubers and other insects could make homes in the original IMPROVE sampler inlet caps which adversely affected data for a few monitoring sites
- The original IMPROVE sampler design made it hard to inspect and clean the inlet caps

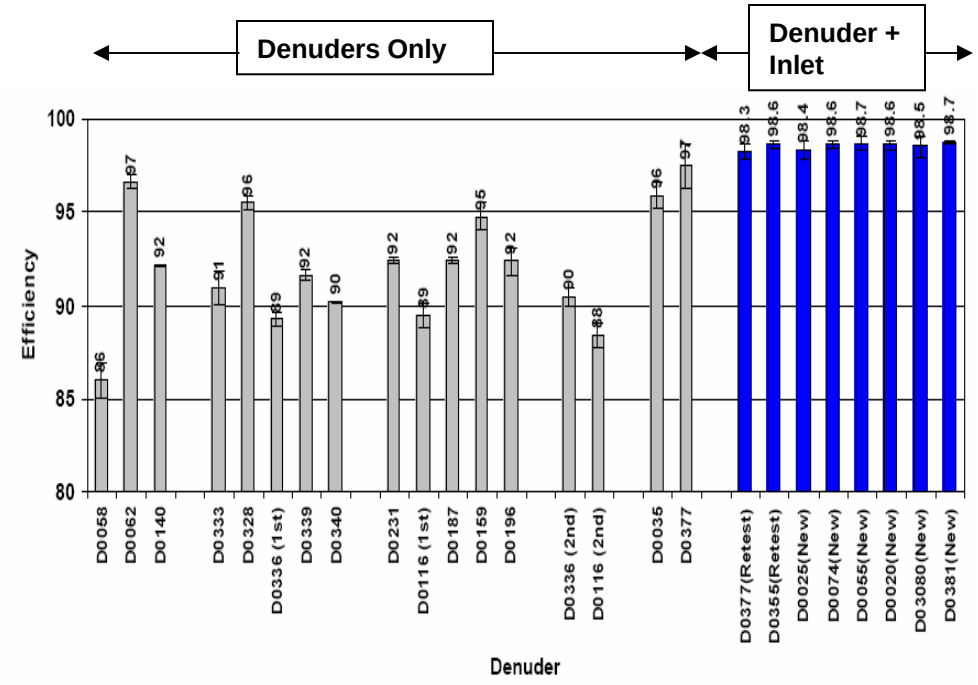
- A new easily inspected and cleaned inlet cap was designed for the version II IMPROVE samplers deployed during the network expansion (~1999)
- Insects can build nest in just a few days so inspections needed to be frequent during certain times of the year to avoid problems

- A screen to help keep the insect out is now being tested to ensure that it doesn't adversely effect aerosol collection efficiency
- If approved the new configuration will be sent to all the sites

Nitric Acid Denuder Testing

- Denuders need to have near 100% efficiency for nitric acid to avoid a positive artifact for particulate nitrate on the nylon filters
- Field testing in 2003 at San Gorgonio (often in the L.A. plume) showed that virtually the same values were obtained with year-old, new, coated and uncoated denuders in spite of high nitric acid concentrations
- Original laboratory testing of denuder efficiency showed values of about 90% (not really good enough and inconsistent with field tests)
- More recent laboratory testing shows that the denuder plus inlet system removes about 99% of the nitric acid





Process to Replace the Thermal-Optical Carbon Analyzer

2003 Issue & Proposal

•Original systems (DRI/OGC analyzers) built in the mid-1980s are antiquated, failing, & no loner supported

•Proposed replacement system (Model 2001 carbon analyzers) are more capable & have better precision

2003 Initial Trials

•Hundreds of ambient and source-specific samples analyzed by both systems using nominally the same operating protocols

•Comparable OC, EC, and TC

•But the thermal fractions (OC1, OC2, etc.) were not comparable

2004 Further Investigations

•Temperature probe placement in the original analyzers were not representative of the sample temperature

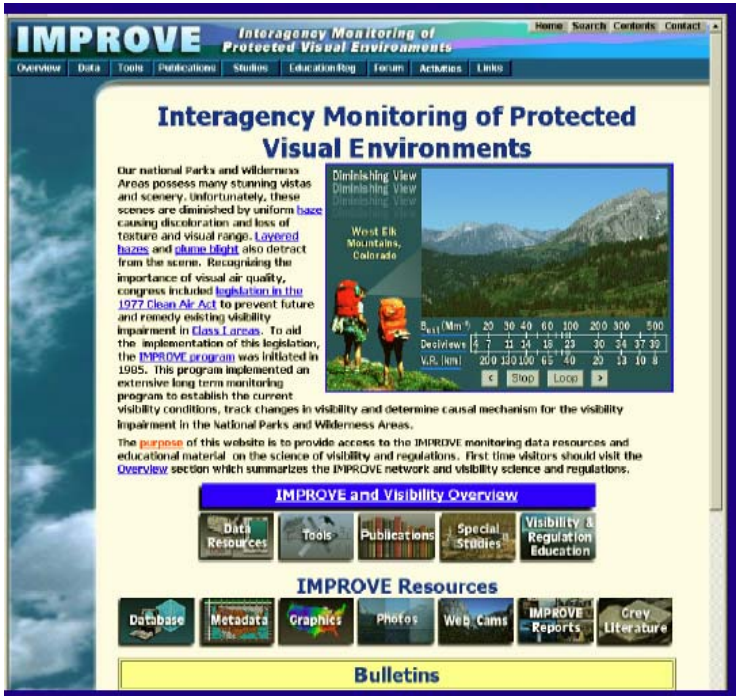
•Diffusion leaks in some of the older analyzers caused small, but sometimes significant oxygen concentrations in the analyzer

•Hundreds of samples analyzed by the original and new system with modified temperatures (IMPROVE-A protocol) to better mimic the original systems show much improved comparability for all carbon fractions

2005 IMPROVE-A protocol approved for use starting 2005

5. Ambient Data and Methods Documentation Accessibility

IMPROVE Web Site



- Data
- Tools
- Publications
- Special Studies
- Education
- Activities

http://vista.cira.colostate.edu/IMPROVE

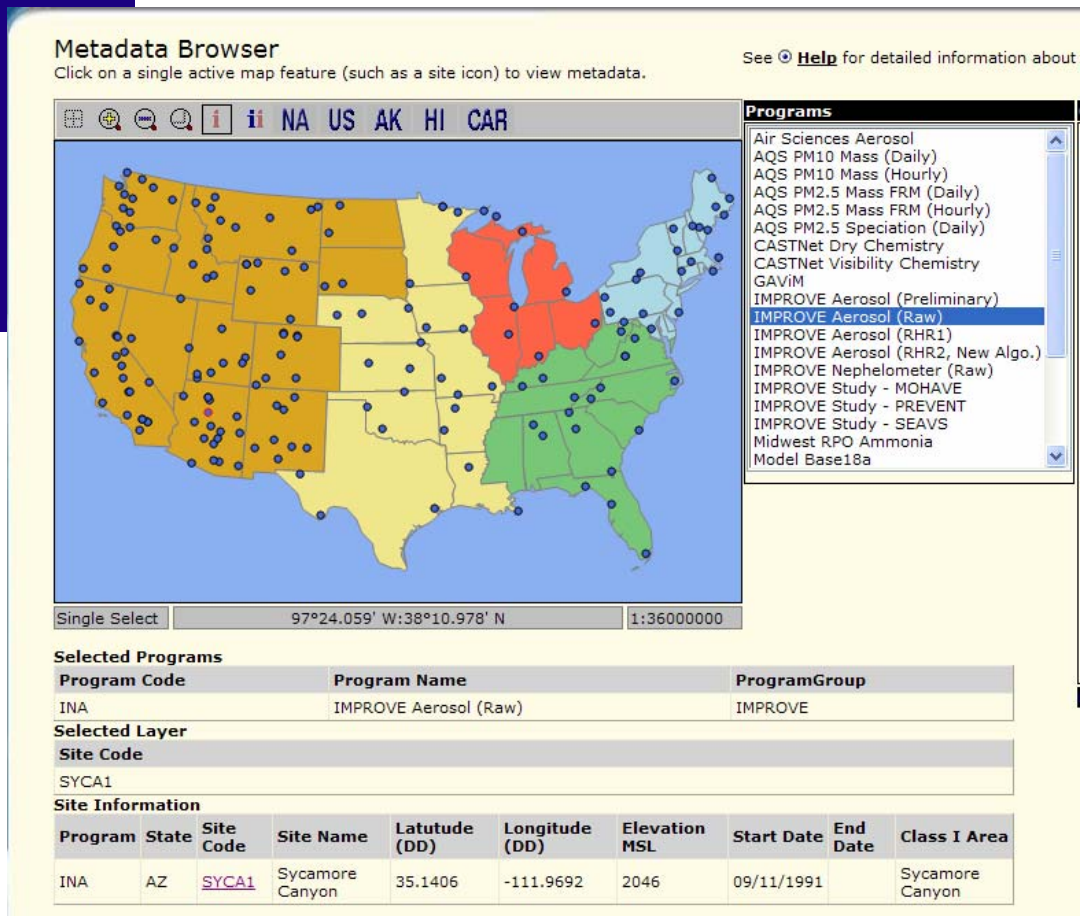
Public archive of

- Grey literature & data advisories
- Quarterly newsletters & Steering Committee meeting summaries
- SOPs & quality assurance documents, special study reports
- IMPROVE Reports & other publications using IMPROVE data

Database & Metadata Browser

Select the network & site:

- Raw & processed data, data summaries & display graphics
- Location, elevation, maps, & photos
- Equipment, site & program histories



Example Data Advisory – 1 Day in 6 Copper Contamination at Some IMPROVE Sites

Sites and Periods – Known

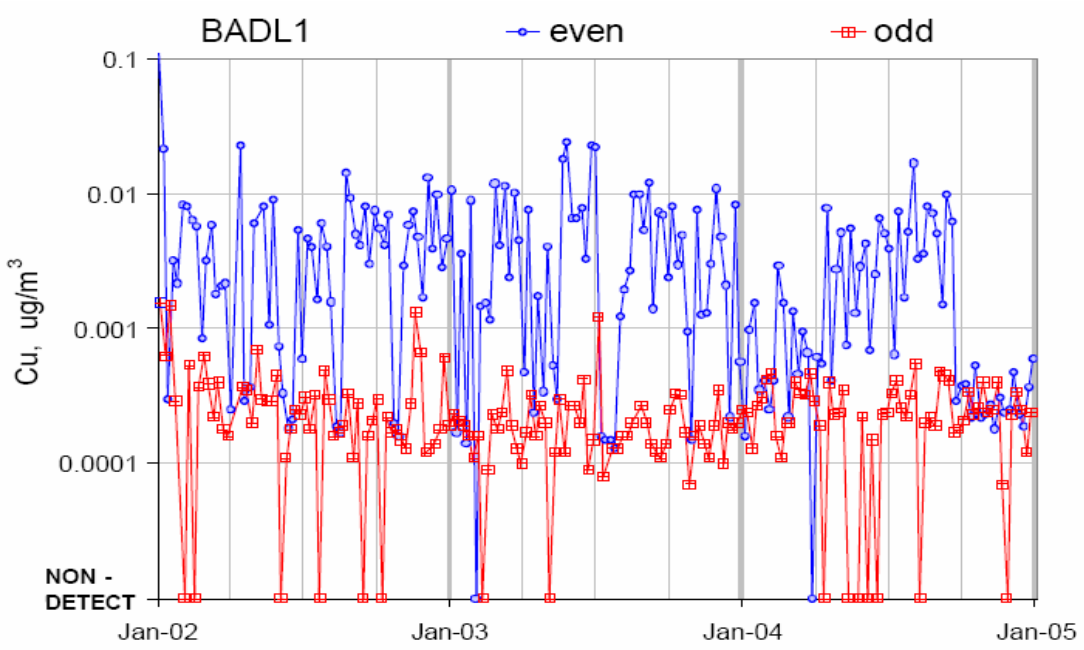
ATLA May – December, 2004*****
BADL January 2002 – September 2004
BRMA January 2002 – December 2003
PMRF July – December, 2002
ROMA January 2002 – December 2004*****

Cause

Collocation with other samplers having brush-type pump motors operating on a 1 day in 6 schedule

Recommendation

Screen copper data for periodic patterns



* Most recent sample date examined

IMPROVE 2006 Report

- Spatial patterns for data from both the IMPROVE and Speciation Trends Networks
- Seasonal patterns for fine and coarse mass species by region
- Aerosol and haze trend assessments
- Recent method assessment and data validation studies including the comparability of IMPROVE and STN data
- Hard copy and electronic version available November 2006

The End! Questions?