

A scenic landscape of snow-capped mountains and a valley with a lake. The foreground shows a rocky, grassy hillside. The middle ground features a valley with a lake and a small town. The background is dominated by a range of mountains with significant snow cover under a blue sky with light clouds.

# Spatial and Seasonal Patterns in Speciated Fine Particle Concentration in the Rural United States

Bret Schichtel NPS

William Malm NPS

Marc Pitchford NOAA/EPA

Lowell Ashbaugh UCD

Robert Eldred UCD

Rodger Ames CIRA



# IMPROVE Monitoring Program

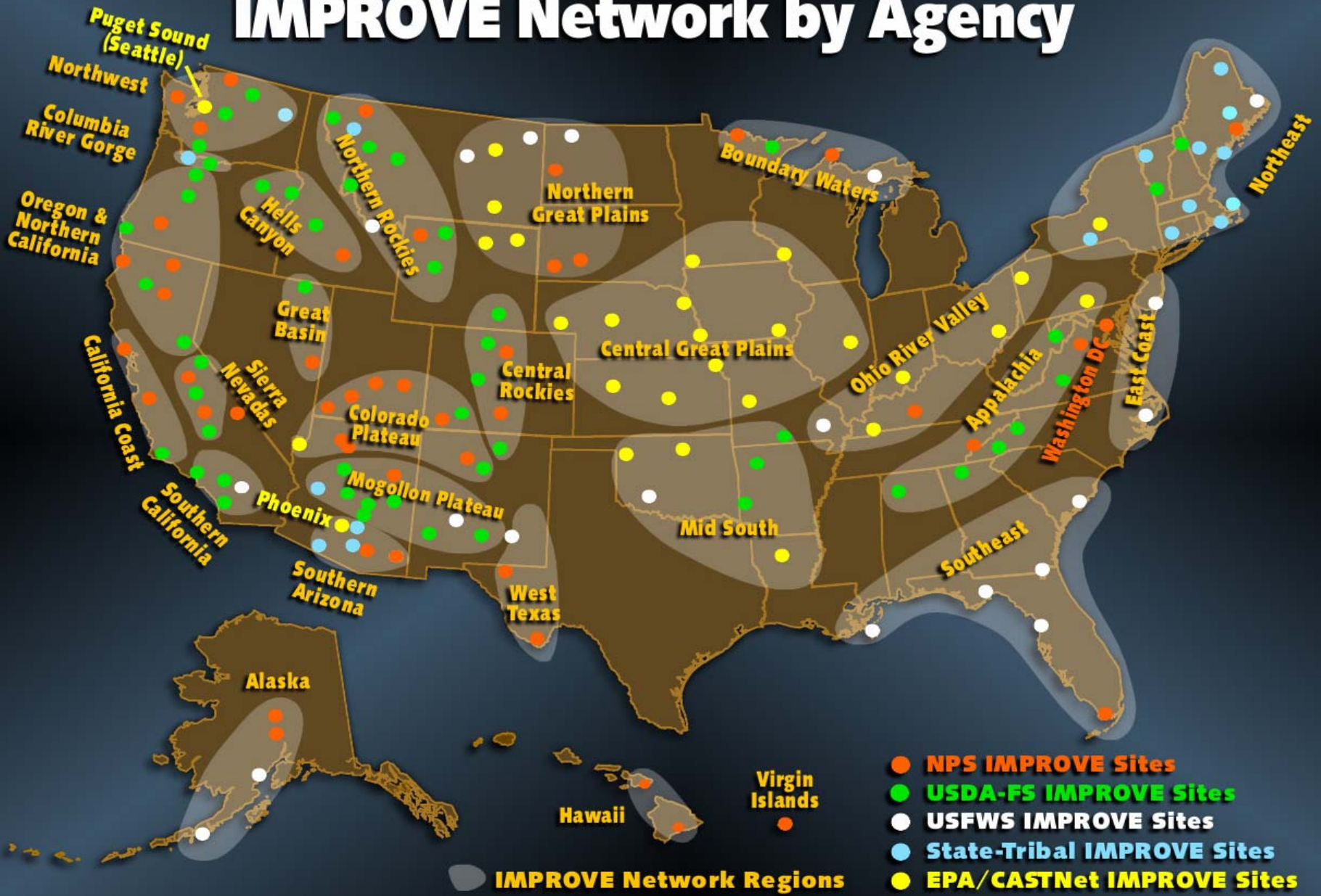
## The Interagency Monitoring of Protected Visual Environments

- A cooperative measurement effort of particulate matter and haze in Class I Areas
- Governed by representatives from Federal and regional-state organizations
- Objectives:
  - Establish current visibility and aerosol conditions in federal class I areas
  - Identify chemical species and emission sources responsible for existing man-made visibility impairment in FCIA
  - Document long-term trends for assessing progress towards the national visibility goal to FCIA
  - With the enactment of the [Regional Haze Rule](#), to provide regional haze monitoring representing all visibility-protected FCIA
- Conduct visibility/aerosol research: Intensive monitoring studies

# IMPROVE Monitoring

- Monitoring Began in March 1988
- **Optical** – extinction by *transmissometer* &/or scattering by *nephelometer* (hourly) plus absorption on particle filters (24-hour)
- **Aerosol** – particle sampling/analysis for six major species & trace constituents to aid in source attribution (24 hour samples twice weekly; every 3<sup>rd</sup> day starting in 2000)
- **Scene** – color *photography* to document scenic appearance (typically 3 photos/day)
  - photographic spectrums of a range of visibility conditions are generated from 5 years of photos

# IMPROVE Network by Agency

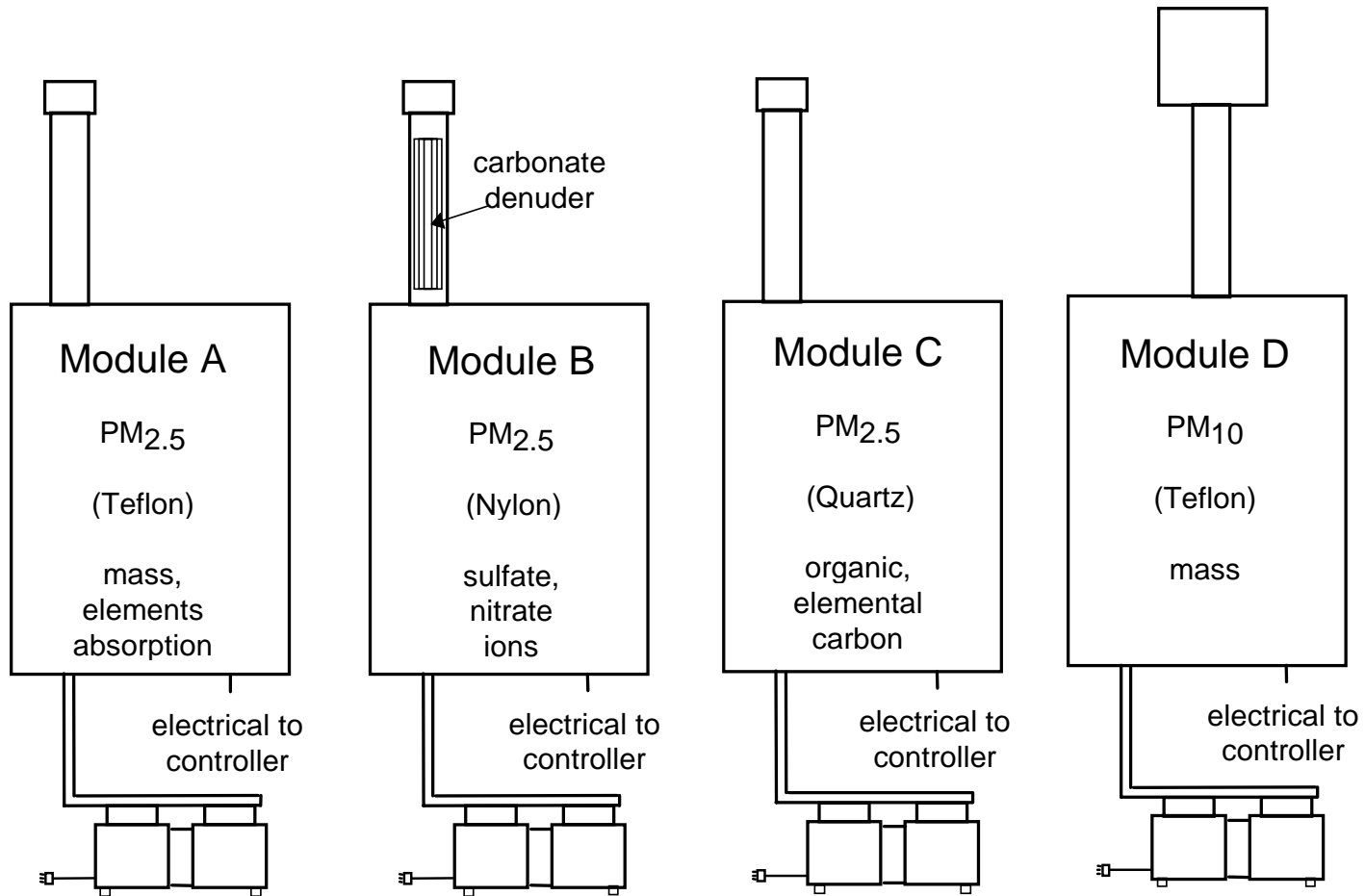


- Began operating in spring of 1988 with 20 monitoring sites
- Today has 165 sites - 54 sites with seven or more years of data.

# Chiricahua, NM



# IMPROVE Aerosol Monitor



## Other Instruments:

- Optical measurements using transmissometers and nephelometers
- Color photography to document the scene

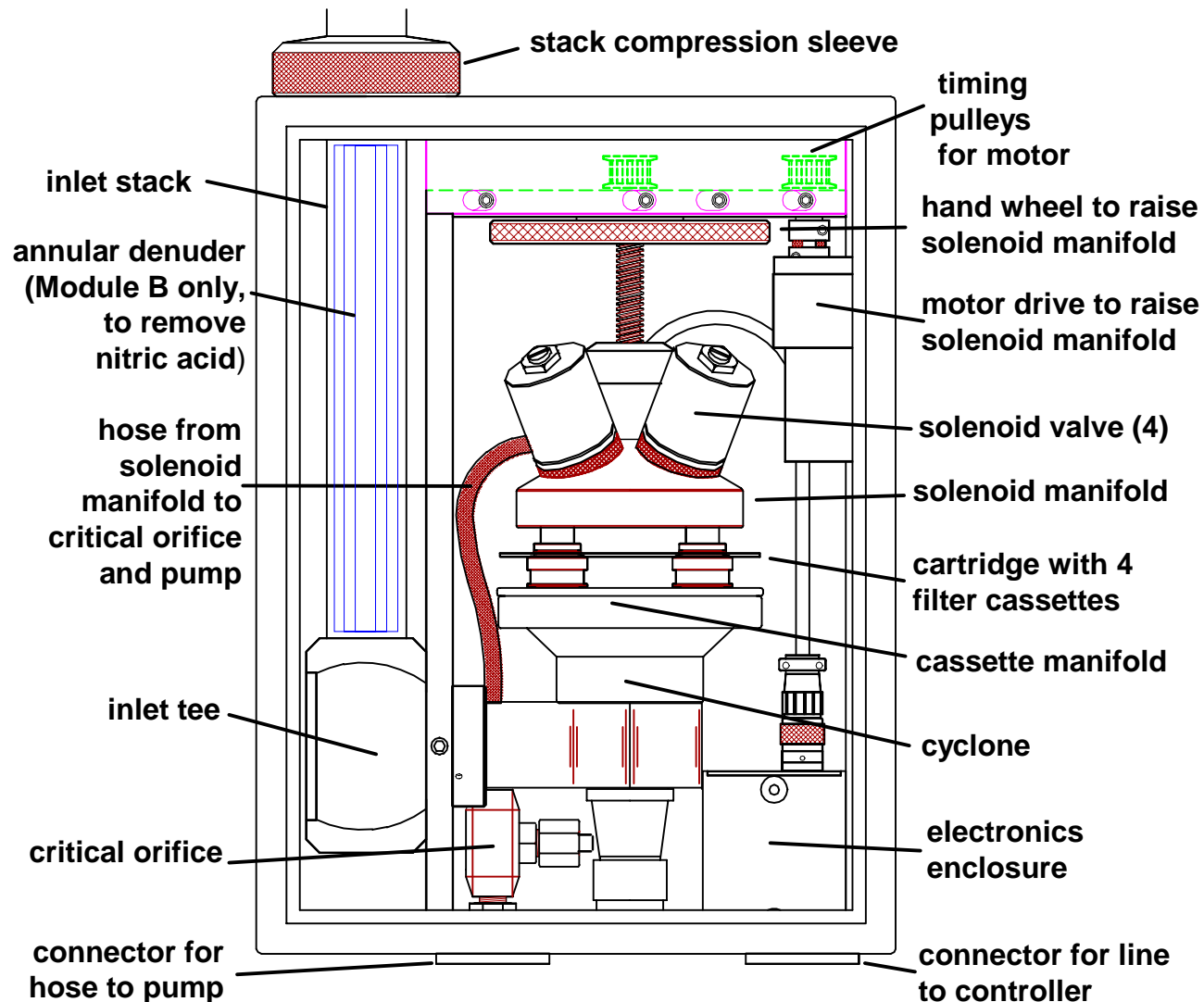
# IMPROVE Aerosol Samplers

- Four independent sampling modules
- Prior to 2000, two 24 hour samples were collected twice a week, after 2000, samples collected every three days.

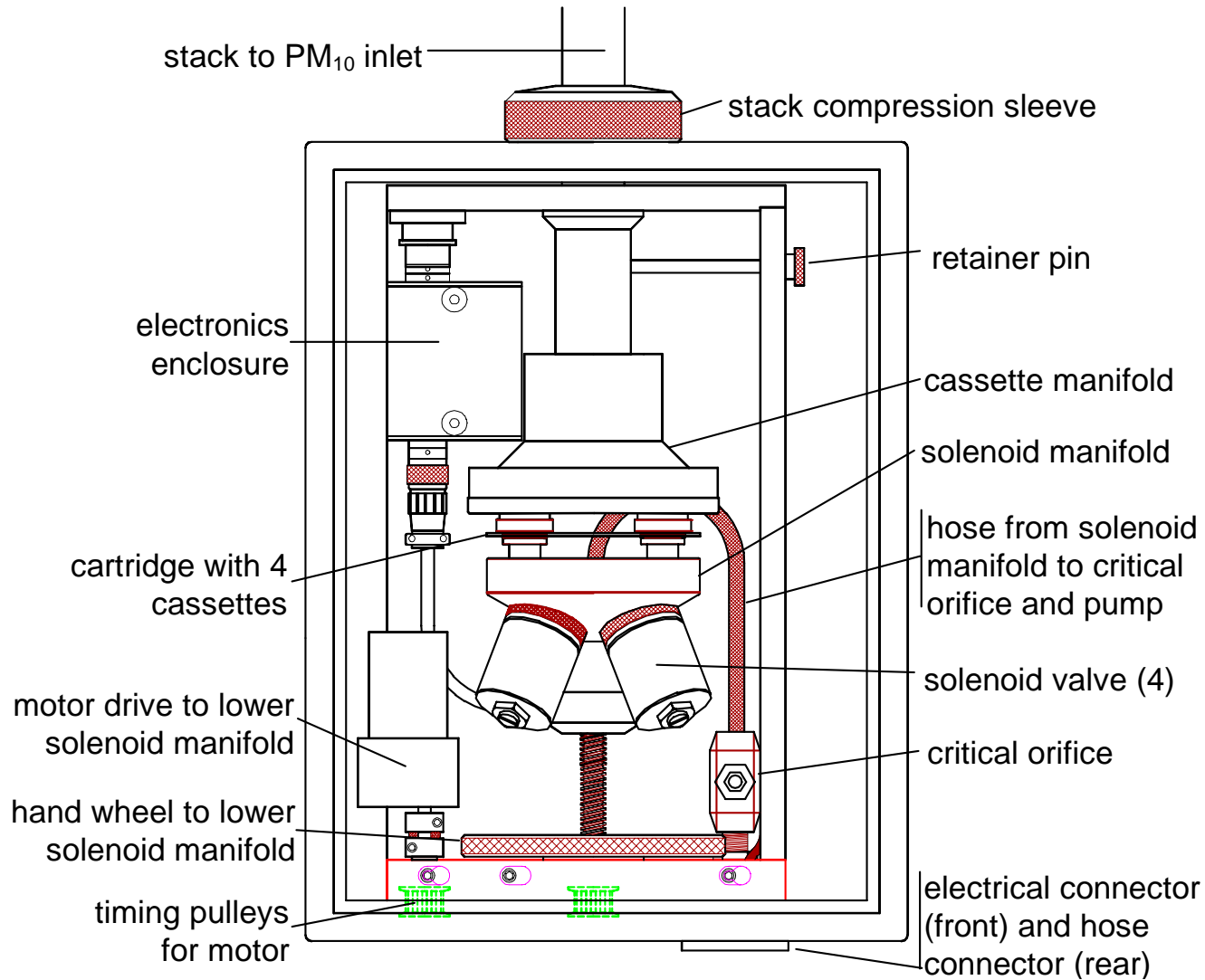
<b>Module</b>	<b>Filter</b>	<b>Size</b>	<b>Variable</b>	<b>Analysis</b>
A	Teflon	PM2.5	mass	gravimetric
			Na-Mn	X-ray Fluorescence – Cu
			Fe-Pb	X-ray Fluorescence - Mo
			total H	Proton Elastic Scattering
			optical absorption	Hybrid Integrating Plate/Sphere
B	Nylon	PM2.5	sulfate, nitrate	Ion Chromatography
C	Quartz	PM2.5	OC, EC in 8 fractions	Thermal Optical Reflectance
D	Teflon	PM10	mass	gravimetric



# IMPROVE modules A, B, C



# IMPROVE module D

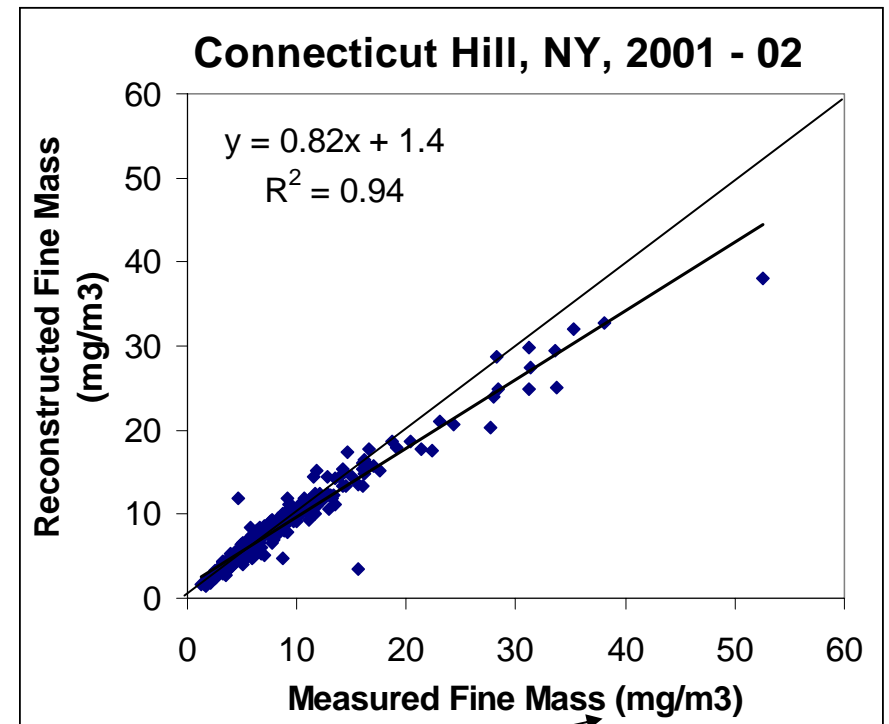
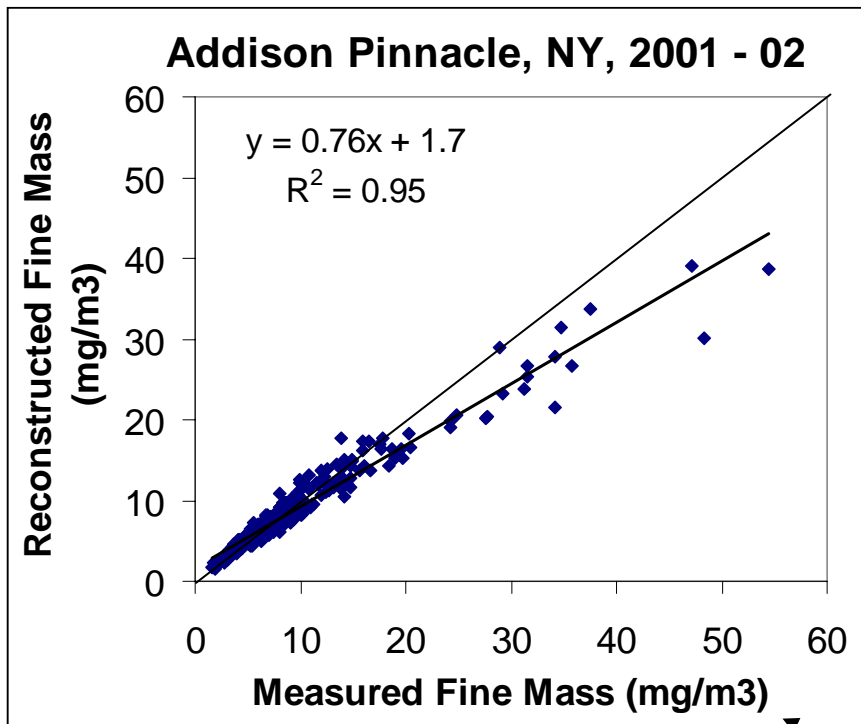


# Aerosol Composite Components

- Ammonium Sulfate –  $4.125 * [S]$
- Ammonium Nitrate –  $1.29 * [NO_3]$
- Organics –  $1.4 [OC]$
- Elemental Carbon –  $[EC]$
- Soil –  $2.2[Al]+2.49[Si]+1.63[Ca]+2.42[Fe]+1.94[Ti]$ 
  - Soil potassium =  $0.6[Fe]$ , FeO and Fe<sub>2</sub>O<sub>3</sub> are equally abundant. A factor of 1.16 is used for other component

# Reconstructed Fine Mass

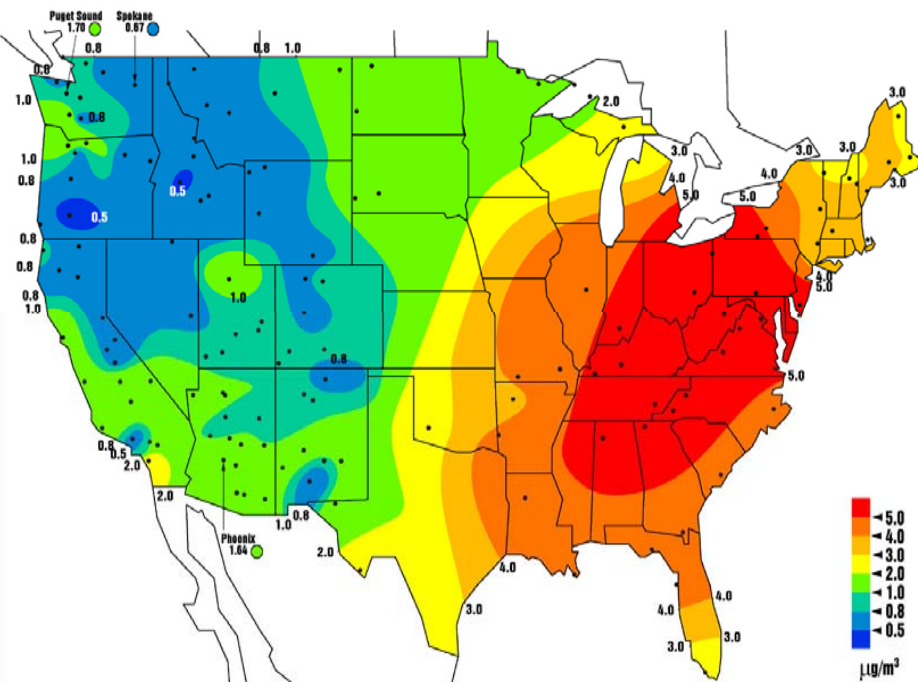
- RCFM = Sulfate + Nitrate + Organics + EC + Soil



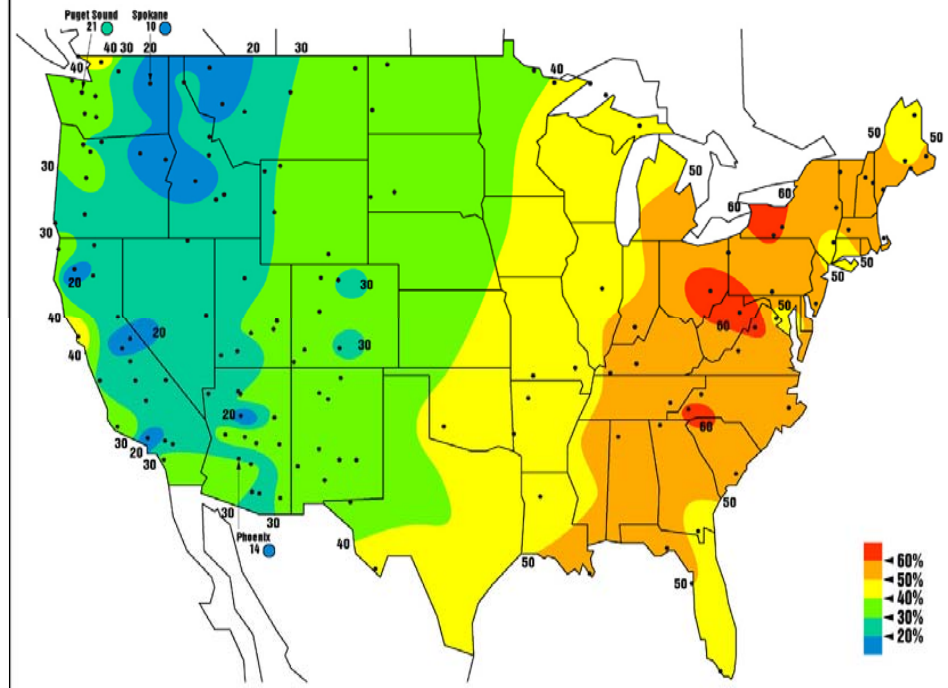
$\mu\text{g}/\text{m}^3$

# Annual Ammonium Sulfate - 2001

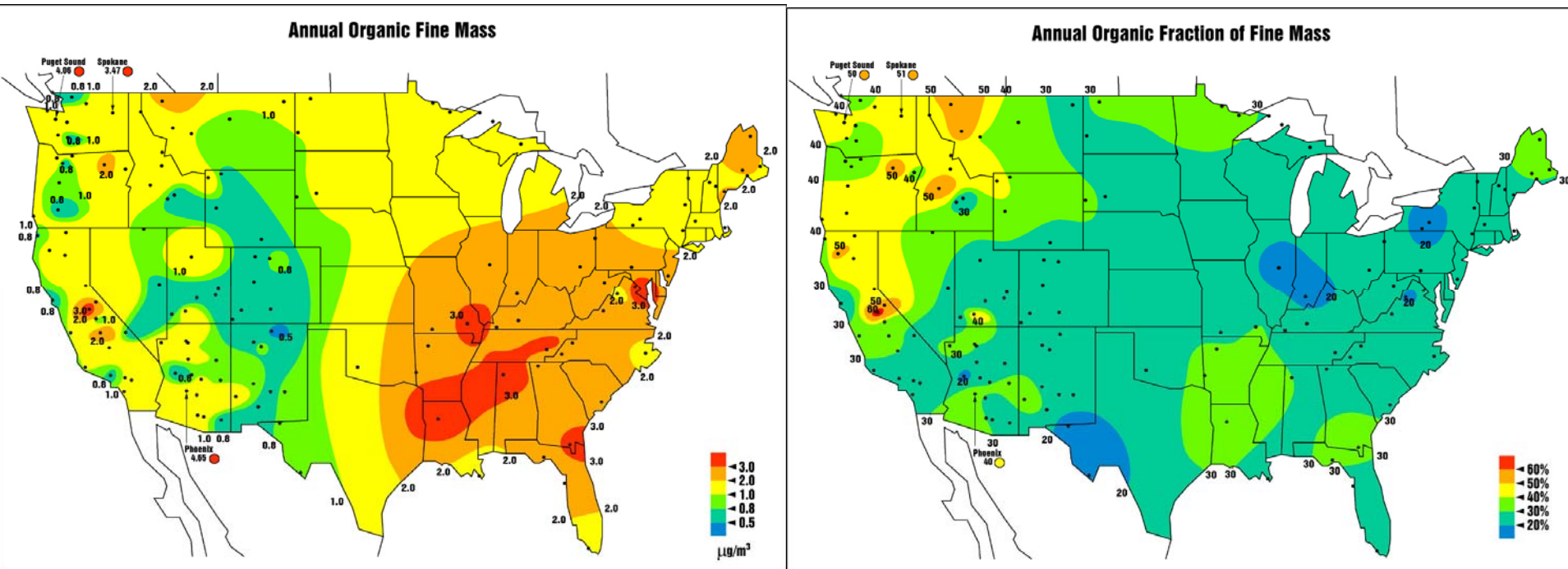
Annual Ammonium Sulfate Fine Mass



Annual Ammonium Sulfate Fraction of Fine Mass

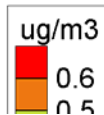
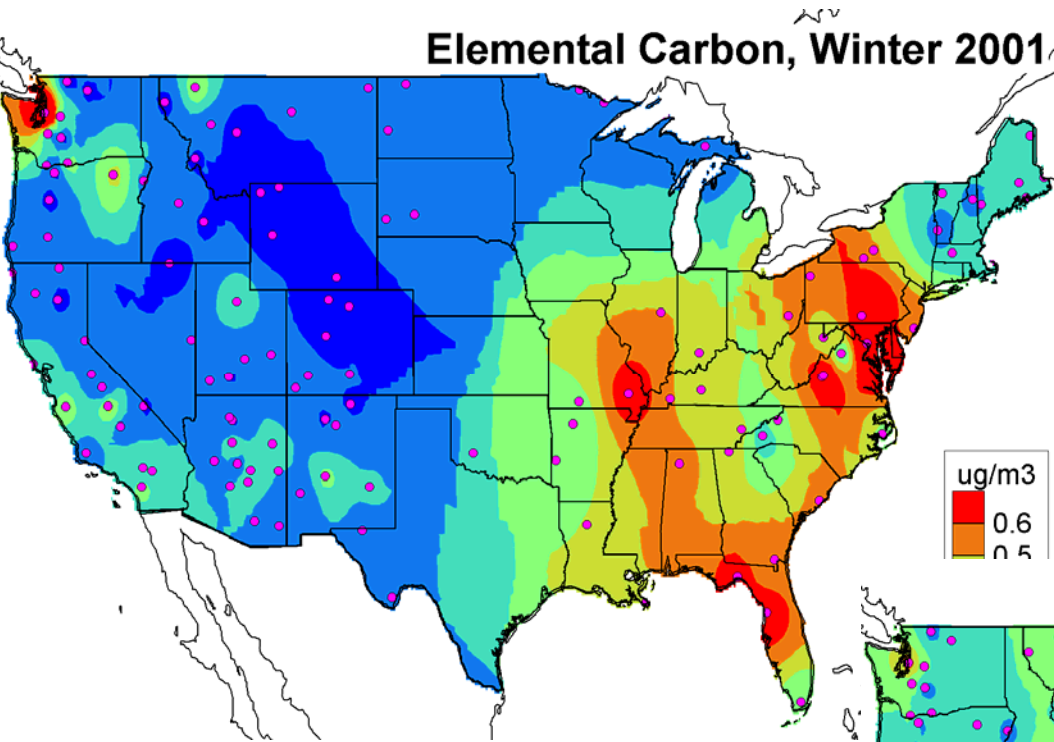


# Annual Organic (1.4\*OC) - 2001

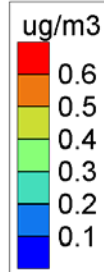
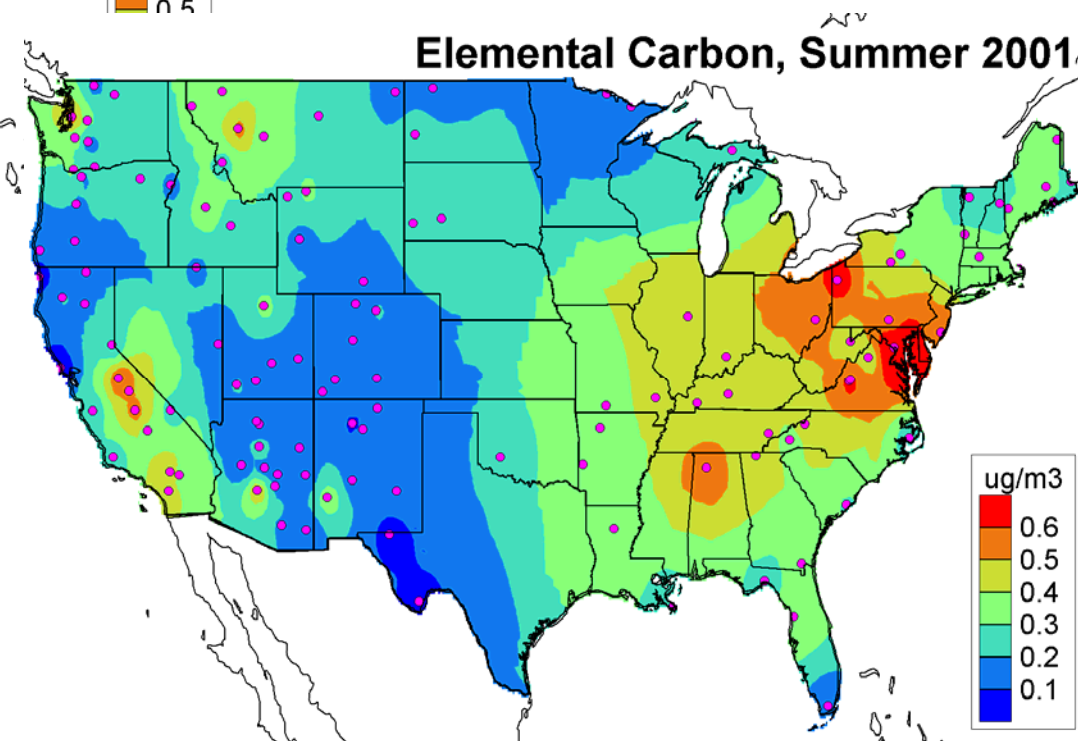


# IMPROVE Elemental Carbon - 2001

Elemental Carbon, Winter 2001

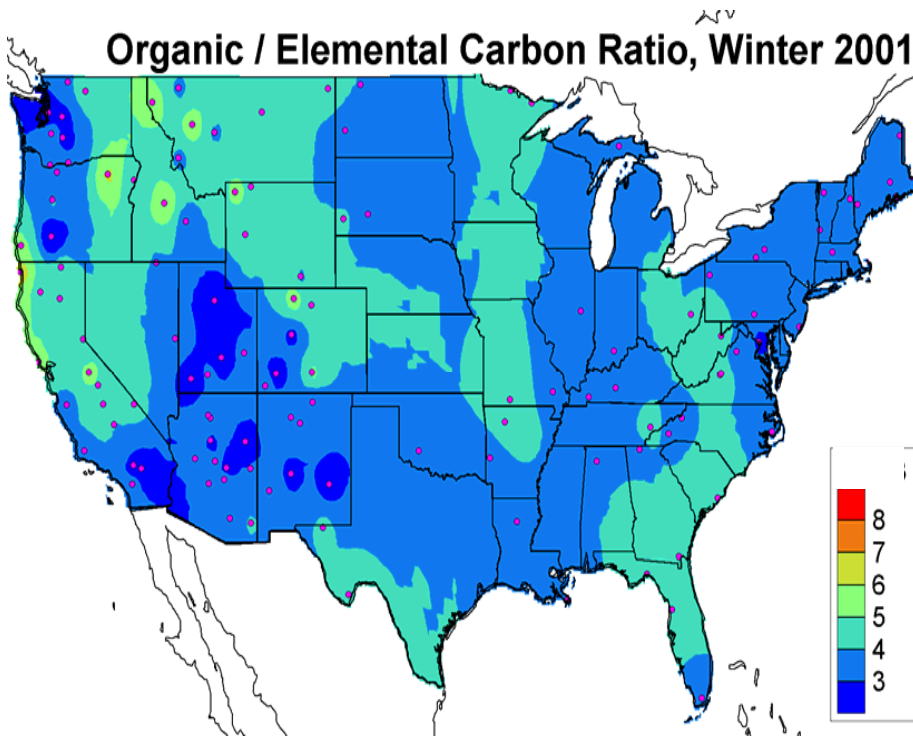


Elemental Carbon, Summer 2001

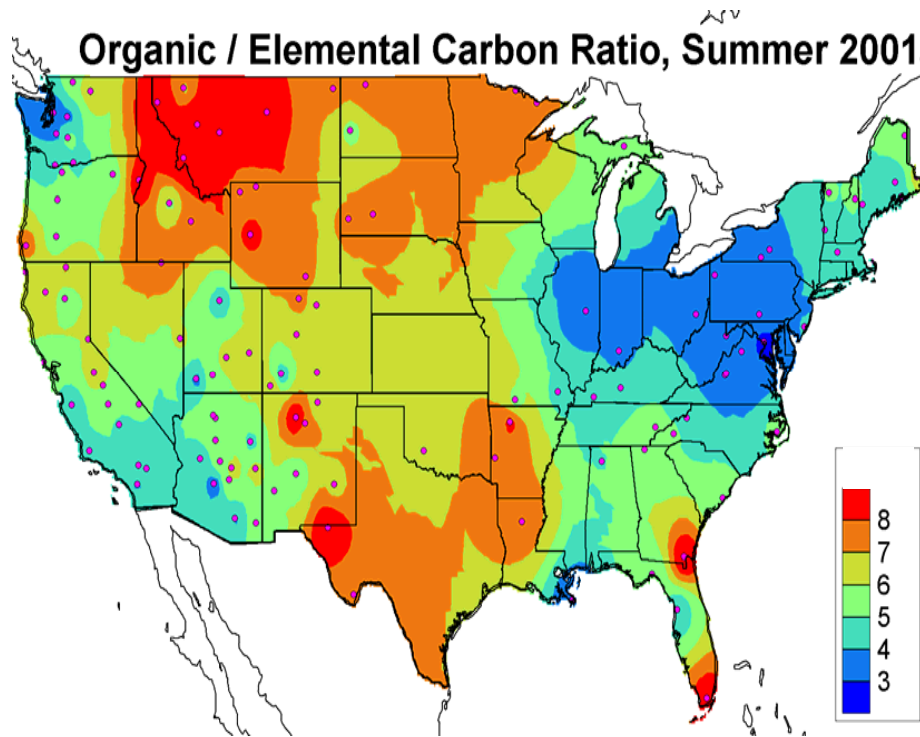


# OC/EC Ratio

Organic / Elemental Carbon Ratio, Winter 2001



Organic / Elemental Carbon Ratio, Summer 2001

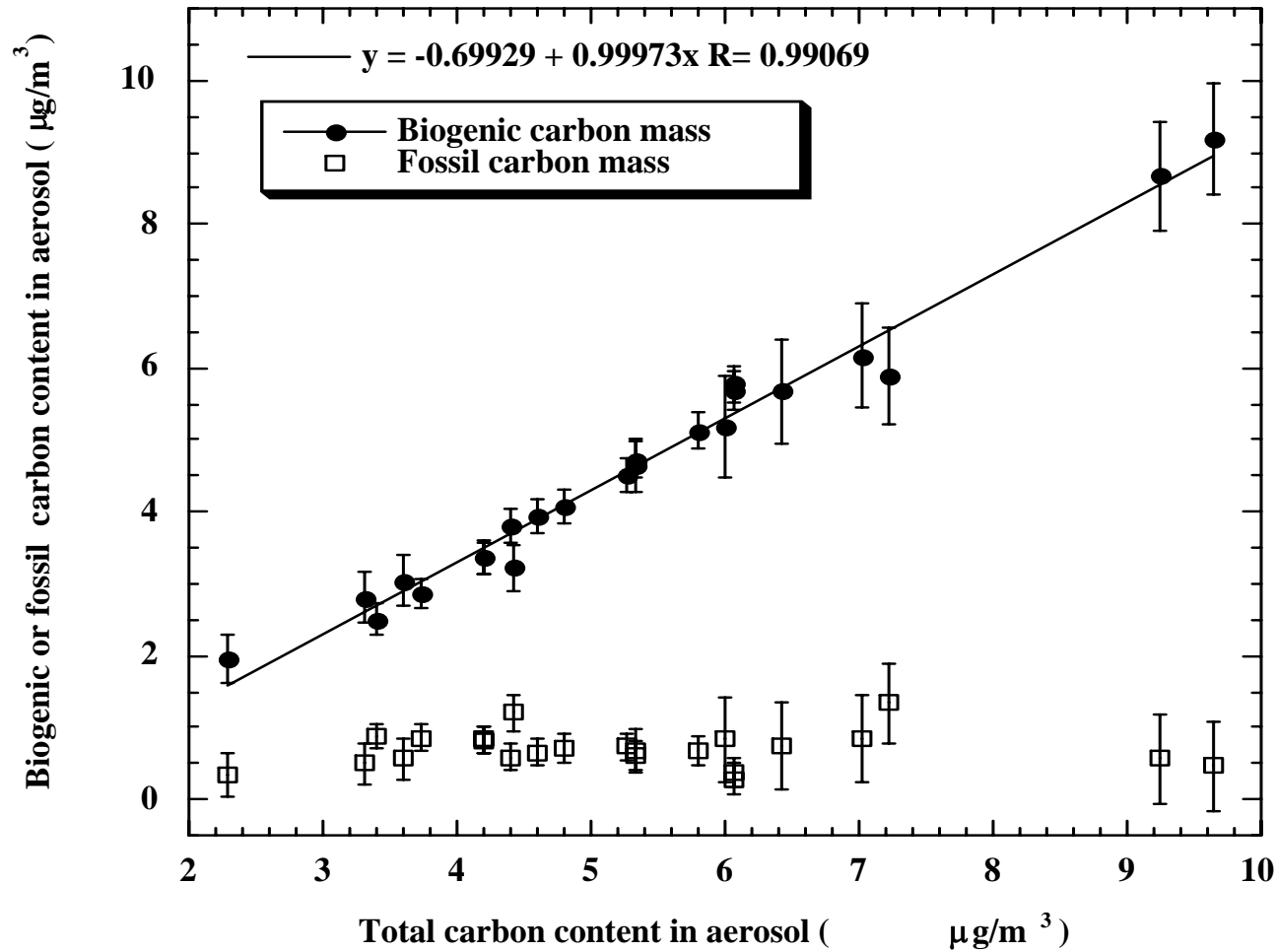


- OC/EC ratio varies between 3 - 5, indicative of more primary urban emissions

- OC/EC > 7 throughout upper West and Texas, Fires?
- OC/EC ~ 3 in Industrial Midwest, primary urban?
- OC/EC > 4-6 in southeast, increased secondary organics?



# Biogenic vs Fossil Carbon – Summer of 2002 at Yosemite National Park

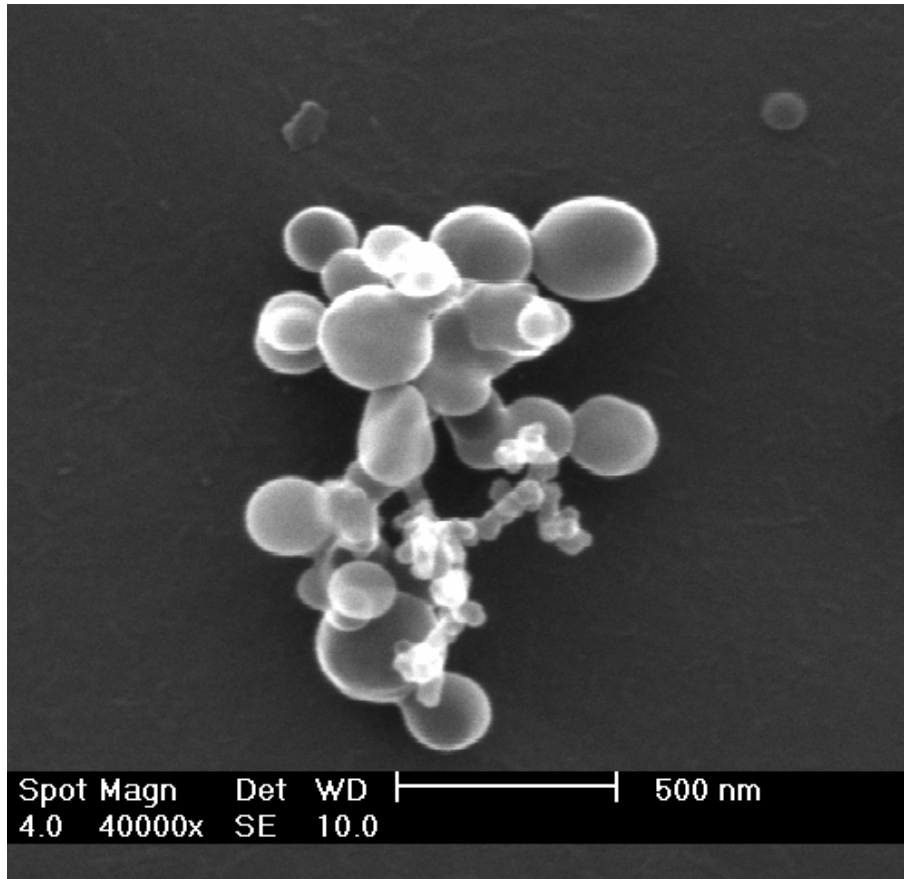


C12 - Old Carbon

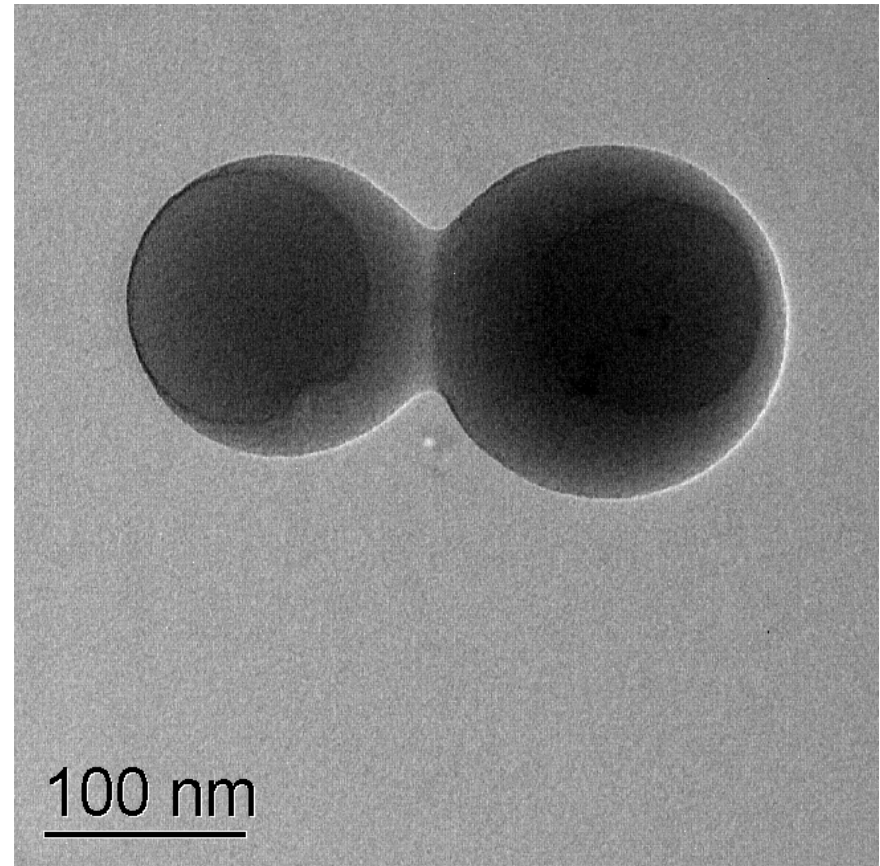
C14 - New Carbon

C14 half life ~ 5000 years

# Election Microscopic images of Carbon Particles Yosemite NP, August 17 2002



Chain of soot particles stuck to an agglomerate of organic “tar balls”

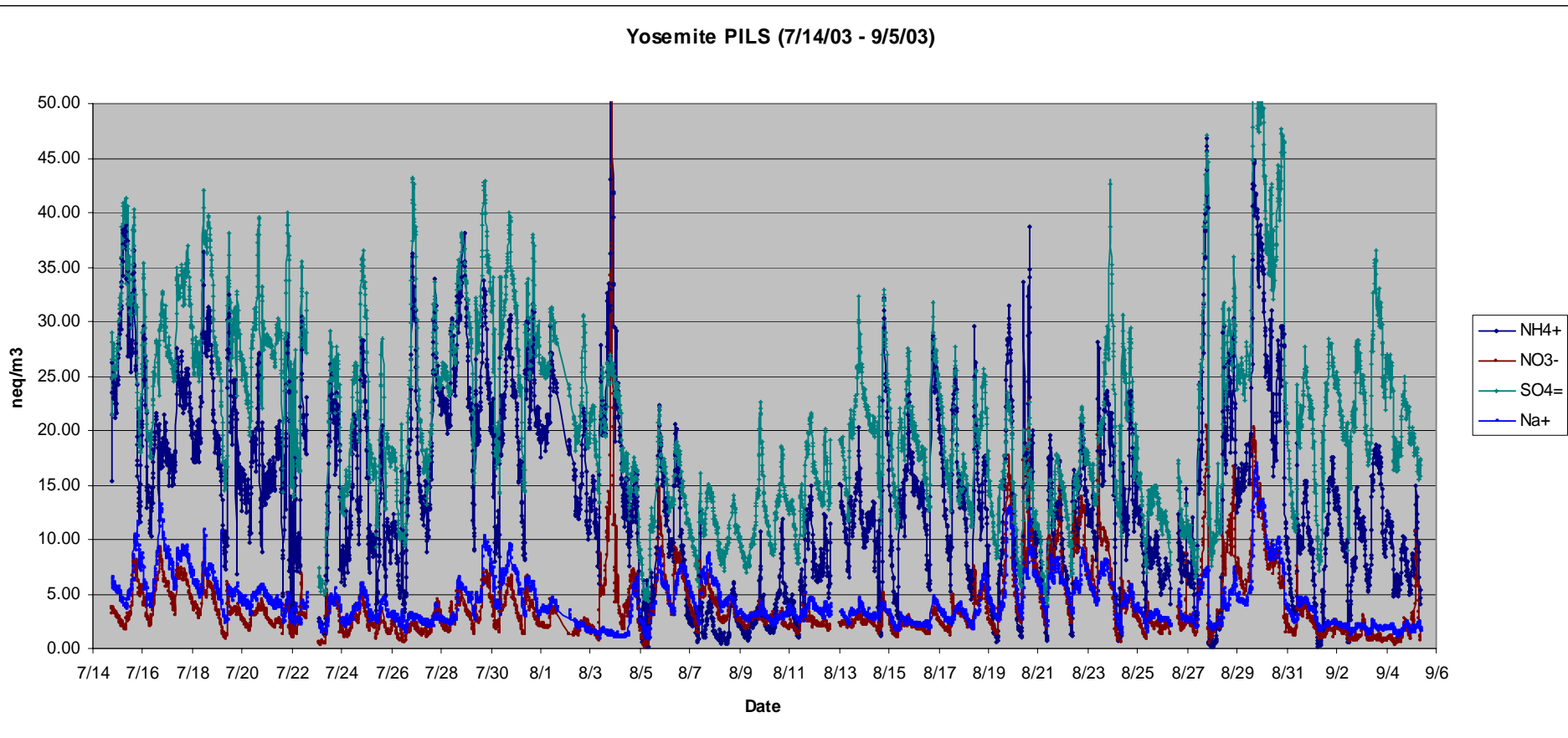


Organic particles with sulfate inclusions (Transmission Election Microscope)



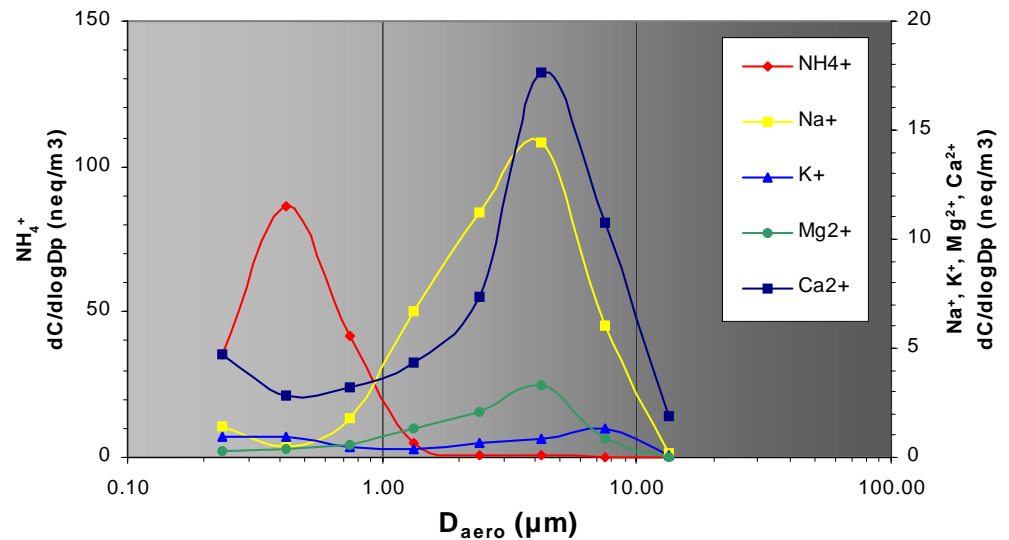
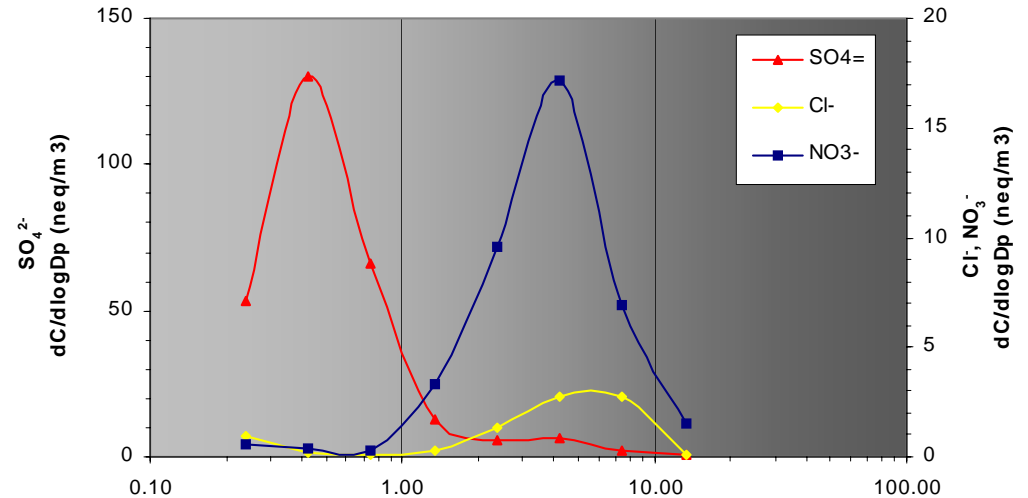
# Yosemite NP Ionic Concentrations PILS

15 minute ion data from the PILS inlet



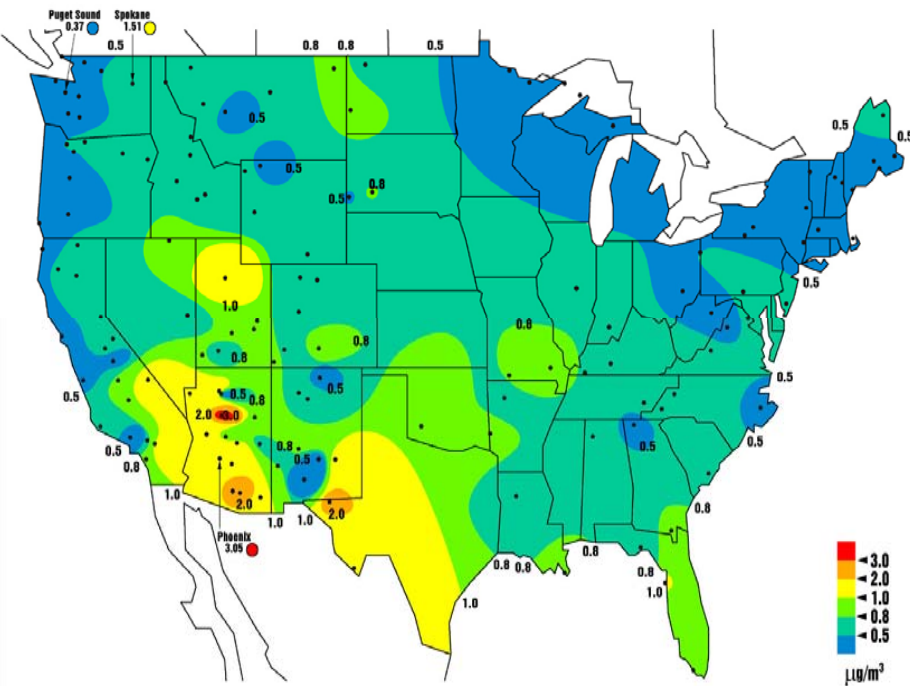
# Big Bend NP Size Distributions - August 1999

- Nitrate found in coarse mode particles
  - Mode size  $\sim 4\text{-}5\ \mu\text{m}$
  - Size distribution similar to  $\text{Na}^+$
- $\text{PM}_{2.5}$  includes tail of coarse mode

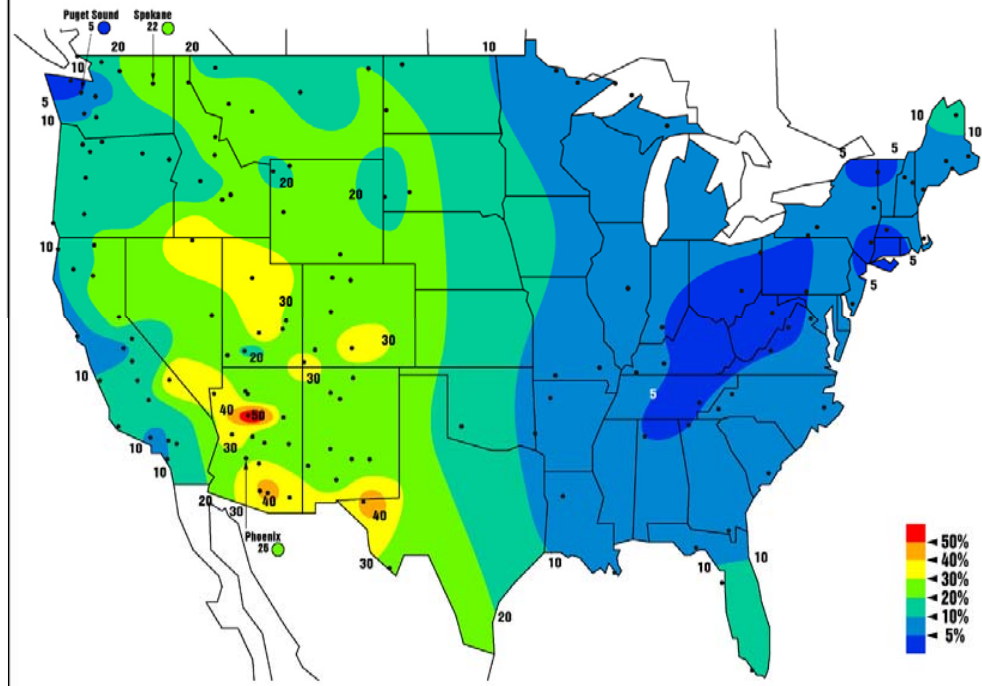


# Annual Fine Soil - 2001

Annual Soil Fine Mass



Annual Soil Fraction of Fine Mass

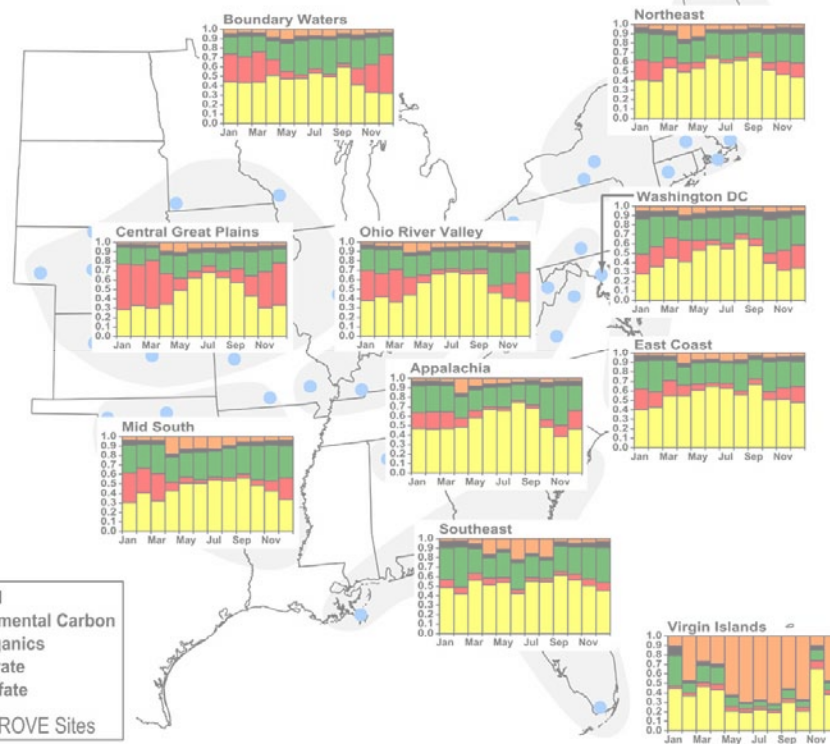
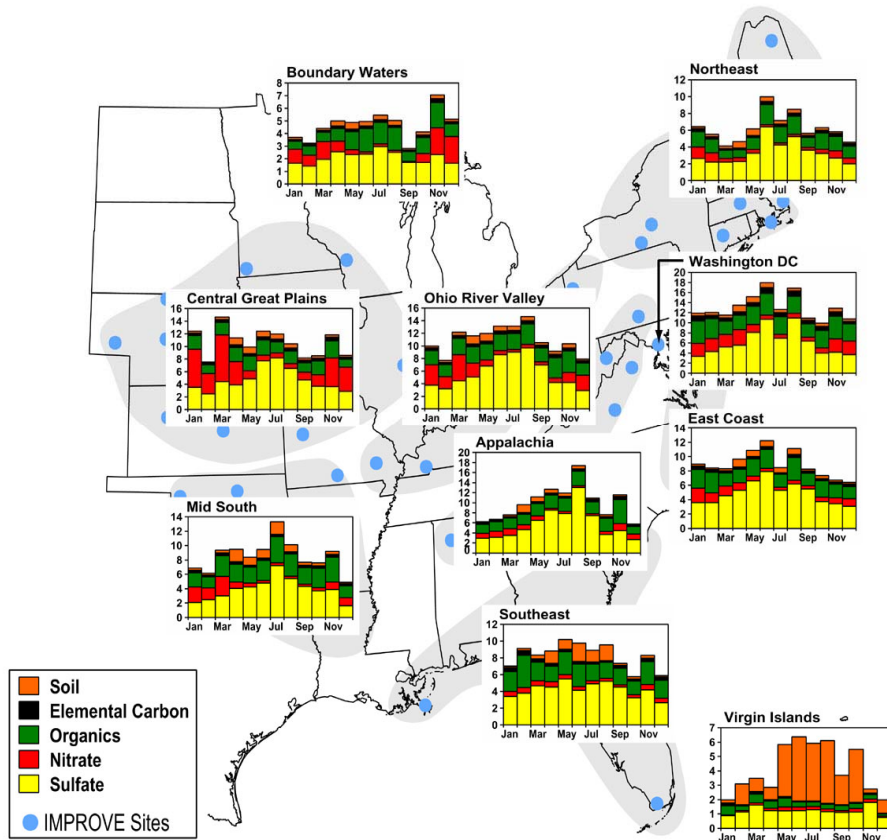


# IMPROVE Network by Agency



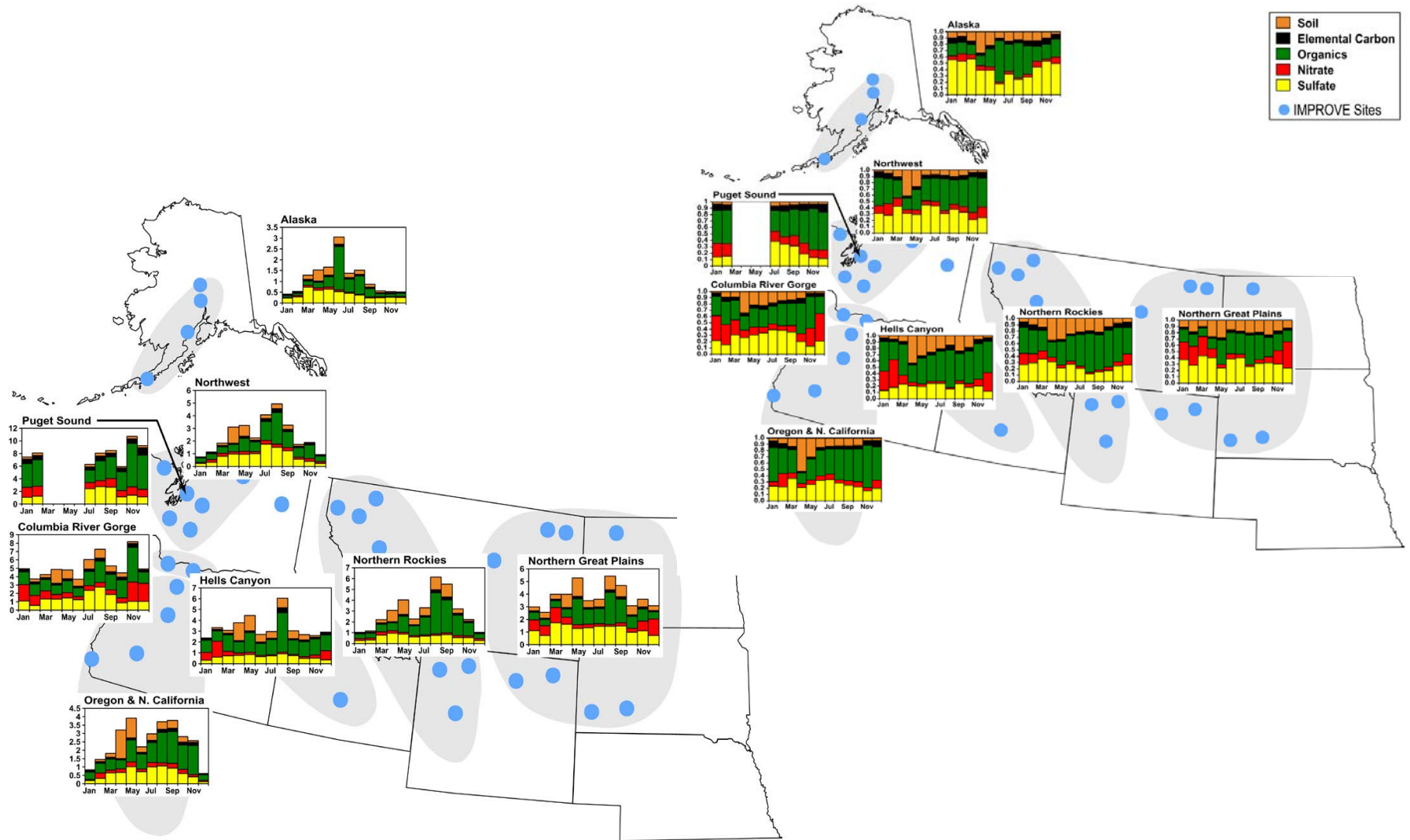
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# Monthly Average Species Concentrations

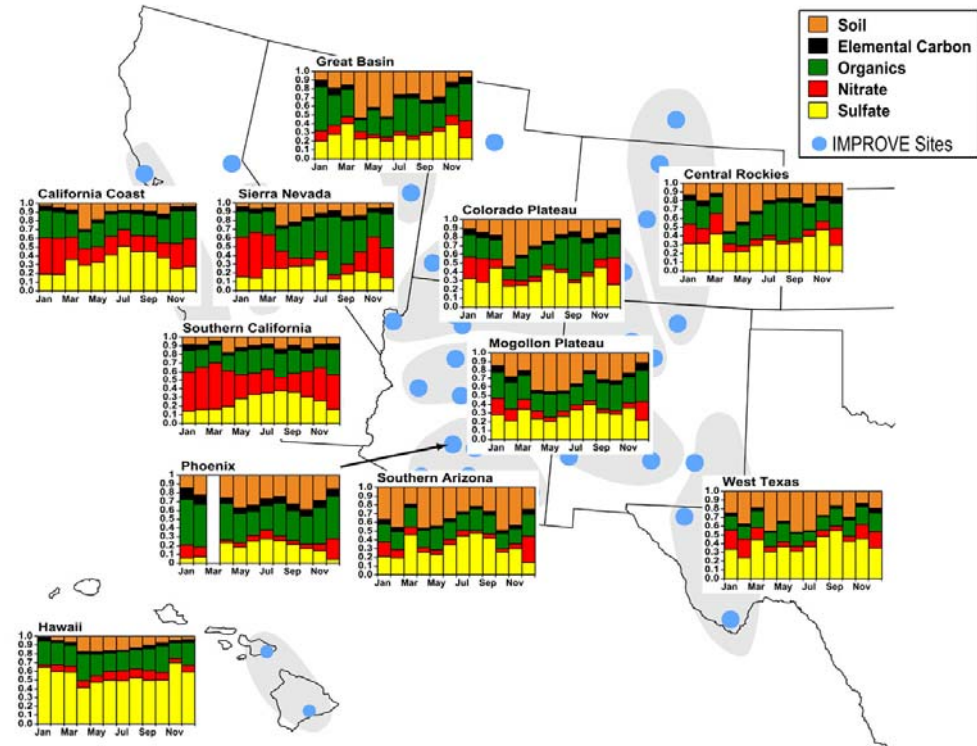
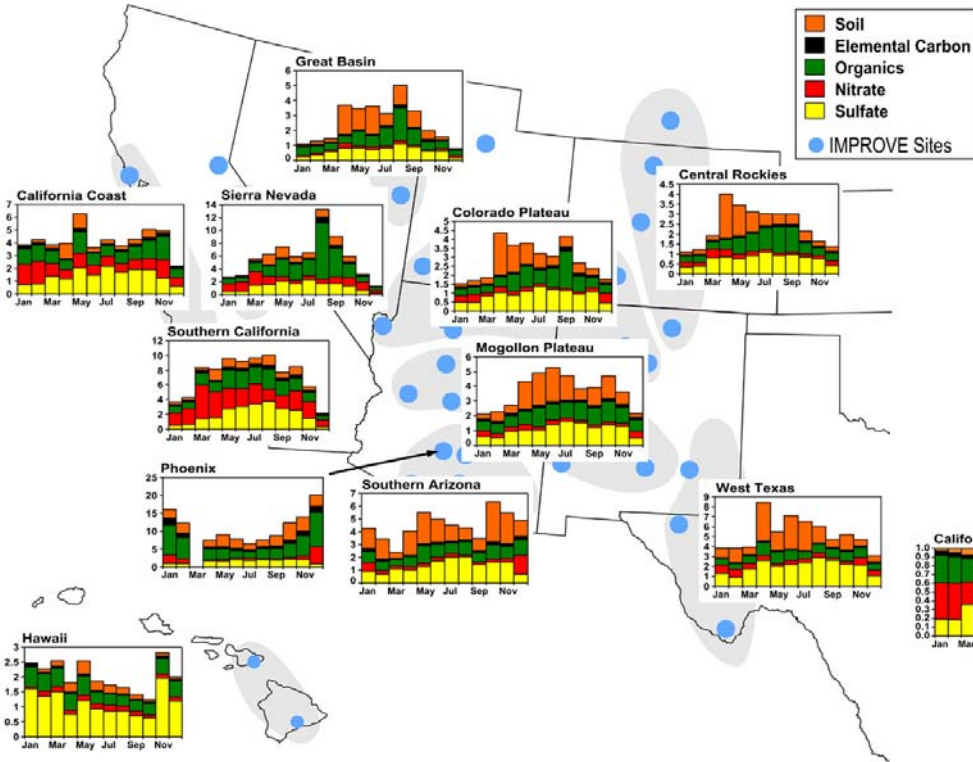




# Monthly Average Species Concentrations



# Monthly Average Species Concentrations



# Data and Information Distribution Visualization and Analysis Websites

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

## Interagency Monitoring of Protected Visual Environments (IMPROVE)

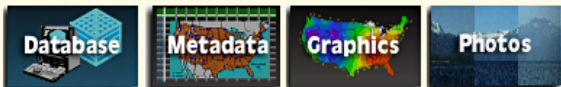
Our national Parks and Wilderness Areas possess many stunning vistas and scenery. Unfortunately, these scenes are diminished by uniform [haze](#) causing discoloration and loss of texture and visual range. [Layered hazes](#) and [plume blight](#) also detract from the scene. Recognizing the importance of visual air quality, congress included [legislation in the 1977 Clean Air Act](#) to prevent future and remedy existing visibility impairment in [Class I areas](#). To aid the implementation of this legislation, the [IMPROVE program](#) was initiated in 1985. This program implemented an extensive long term monitoring program to establish the current visibility conditions, track changes in visibility and determine impairment in the National Parks and Wilderness Areas.

The [purpose](#) of this website is to provide access to the IMPROVE educational material on the science of visibility and regulatory [Overview](#) section which summarizes the IMPROVE network a

### IMPROVE and Visibility



### IMPROVE Resources



### Bulletins



## VIEWES

Visibility Information Exchange Web System

Home What's New Tour Site Map Contact Us Your Account

- Data
  - All Data
  - Metadata
  - Query Wizard
  - ASCII Data Files
- Annual Summary
  - Spatial Patterns
  - Composition
  - Trends
  - Back Trajectories
  - Summary Data
  - Archived Graphics
- Catalogs
  - Air Quality Catalog
  - Weather Catalog
  - Emissions Catalog
- Imagery
  - Visibility Photos
  - Class I Webcams
  - Forest Service

Guest List

For best results, please use:  
Internet Explorer 5 (or higher)  
Netscape 6 (or higher)

Dedicated to reducing [Regional Haze](#) in [Class 1 Areas](#) through the exchange of [Data, Tools, and Ideas](#)



The Visibility Information Exchange Web System is an online exchange of visibility data, research, and ideas designed to support the Regional Haze Rule enacted by the U.S. Environmental Protection Agency (EPA) to reduce regional haze in national parks and wilderness areas. In addition to this primary goal, VIEWES supports global efforts to better understand the affects of air pollution on visibility and to improve air quality in general.



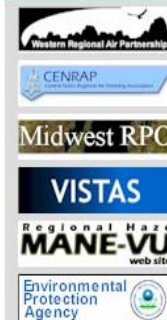
### VIEWES Data

The VIEWES website provides access to a wide variety of visibility data resources, including metadata from several networks of air quality monitoring sites, an integrated aerosol database, graphical summaries of data analyses, extensive catalogs of air quality information, and many others. ( \* [Mouse-over the icons above for more info.](#) )

### QUICK VISITOR'S GUIDE

- Use the top navigation bar for general information about the website.
- Use the left navigation area to browse and search for **data**.
- Click on the photographs at the very top to find out more about selected Class I Areas.
- Learn about the Regional Planning Organizations by following the **"Partners"** links.
- Click on the VIEWES logo to to download the logo in various formats and sizes.

### PARTNERS



### OF INTEREST

- [Visibility](#)
- [About Air Pollution](#)
- [Regional Haze Rule](#)
- [Class I Areas](#)
- [IMPROVE Program](#)
- [RPO Information](#)
- [Software Tools](#)
- [Our Staff](#)
- [Fire & Air Presentations](#)

### NEWSLETTER

Signup for the VIEWES

<http://vista.cira.colostate.edu/VIEWES>

**END**