IMPROVE Aerosol Monitoring Network

Bret A. Schichtel and William C. Malm
National Park Service and CIRA, Colorado State University

Rodger B. Ames
CIRA, Colorado State University

Robert A. Eldred and Lowell L. Ashbaugh
Crocker Nuclear Laboratory, University of California, Davis

Marc L. Pitchford
NOAA, Las Vegas

IMPROVE Monitoring Program

The Interagency Monitoring of Protected Visual Environments

- Established in 1985 to aid the creation of Federal and State implementation plans for the protection of visibility in Class I areas - 1977 CAA amendments
- A cooperative measurement effort 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 provided regional haze monitoring representing all visibility-protected FCIA
- Key participant in visibility-related research:

IMPROVE Monitoring

- Monitoring Began in March 1988
- **Aerosol** – particle sampling/analysis for six major species & trace constituents to aid in source attribution (24 hour samples twice weekly; every 3rd day starting in 2000)
- **Optical** – extinction by **transmissometer** &/or scattering by **nephelometer** (hourly) plus absorption on particle filters (24-hour)
- **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 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.

Module	Filter	Size	Variable	Analysis
A	Teflon	PM2.5	mass	gravimetric
			Na-Mn	Proton Induced X-Ray Emission (PIXE)
			Fe-Pb	X-ray Fluorescence (XRF)
			total H	Proton Elastic Scattering
			optical absorption	Hybrid Integrating Plate/Sphere (HIPS)
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

Big Bend National Park Monitoring Site

•Began with 20 sites in 1988, today 163 monitoring sites are in operation

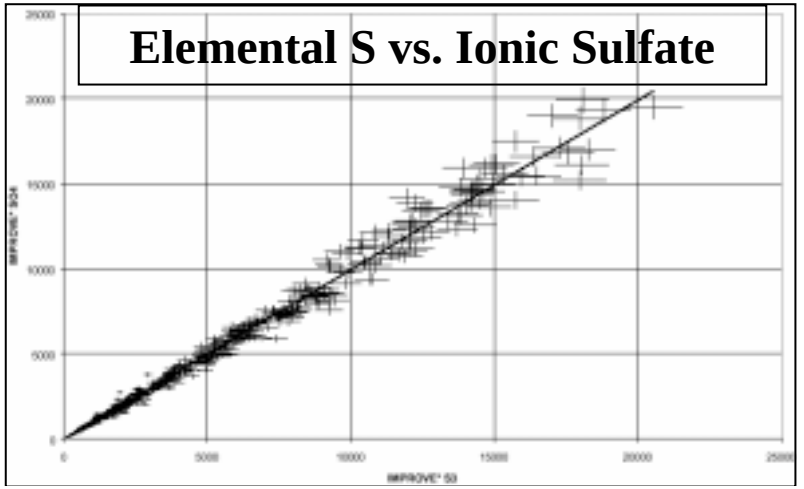
•116 monitoring sites collected some data in 2000

Data Quality Assurance

- IMPROVE data go through extensive QA/QC procedures by UC Davis, NPS/CIRA and users

- Begins at filter purchase
  - Acceptance tests
- Pre-weight measurement
  - Enters sample into log file for tracking
- Post-sample tests
  - Field and laboratory control filters
  - Log sheets
  - Flow rates

- Post-analysis tests
  - PIXE vs. XRF
  - Sulfur vs. sulfate
  - B_{abs} vs. LAC
  - OMC vs. OMH
  - $PM_{2.5}$ mass vs. PM_{10} mass
  - Reconstructed mass vs. mass

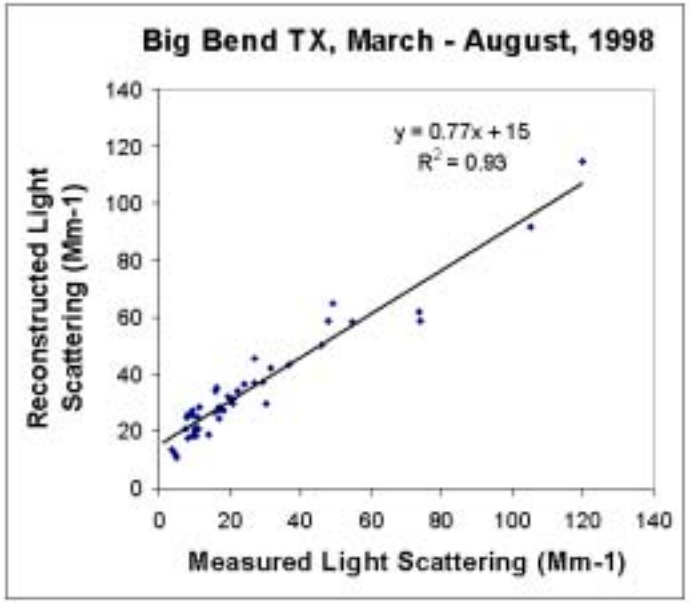


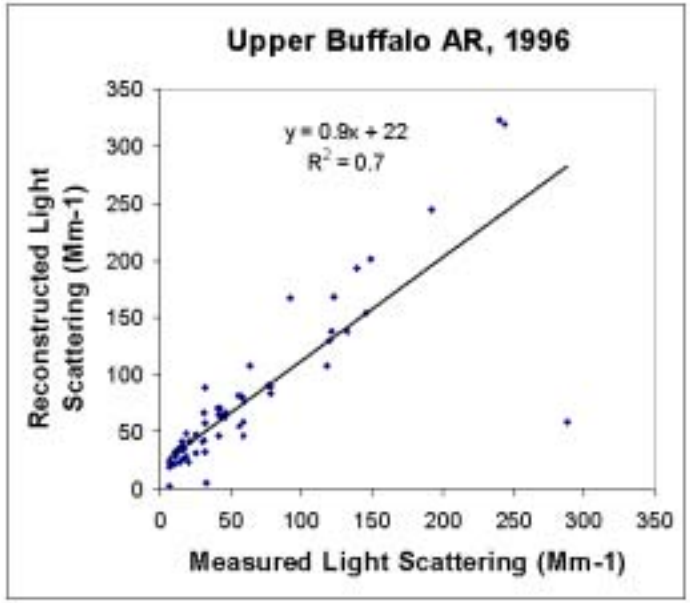
IMPROVE aerosol data are used to estimate haze (b_{ext}) in class I areas (rural United States)

Reconstructed light extinction equation:

$$Light\ Extinction\,(b_{ext}) = 3f(RH)[Amm.sulfate] + 3f(RH)[Amm.nitrate] + 4[Organic] + 10[Light\ Abs.Carbon] + 1[Soil] + 10$$

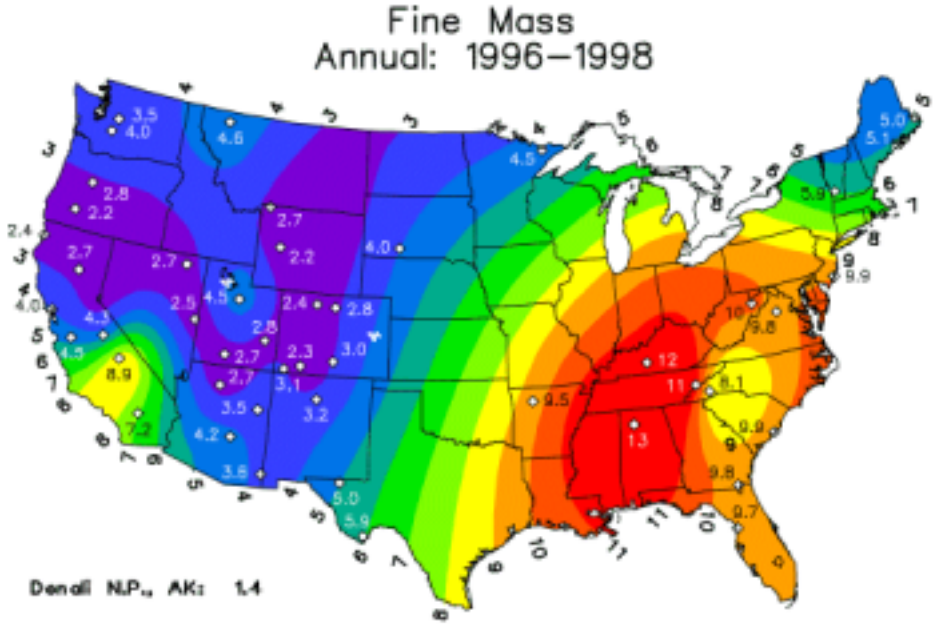
The aerosol types are calculated from the speciated aerosol data, e.g. Amm Sulfate = 4.125 * Sulfur. The leading coefficient are extinction efficiencies [m^2/g] and the f(RH) factor accounts for water uptake by the sulfate and nitrate species.

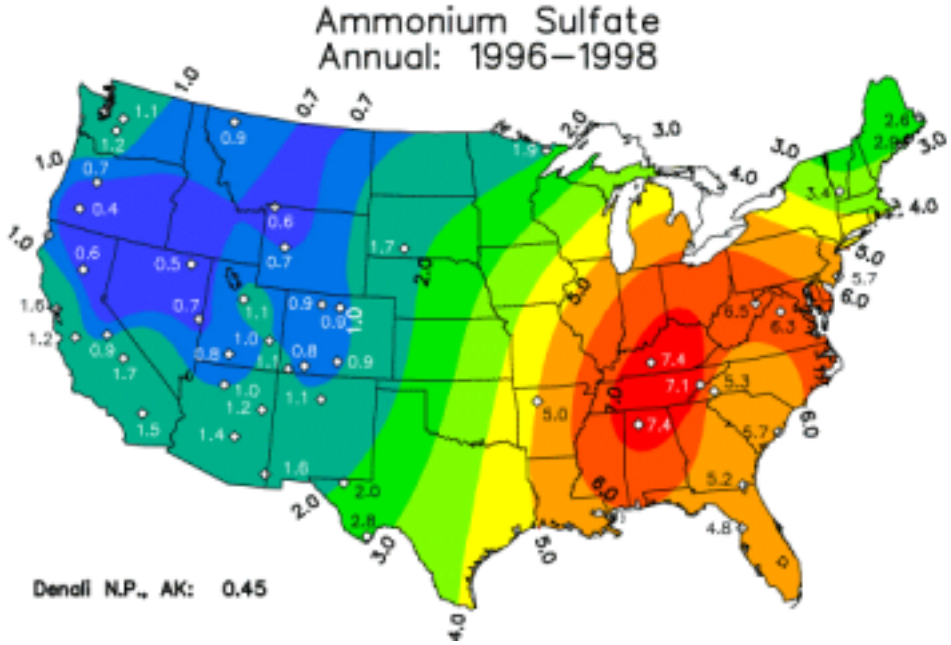


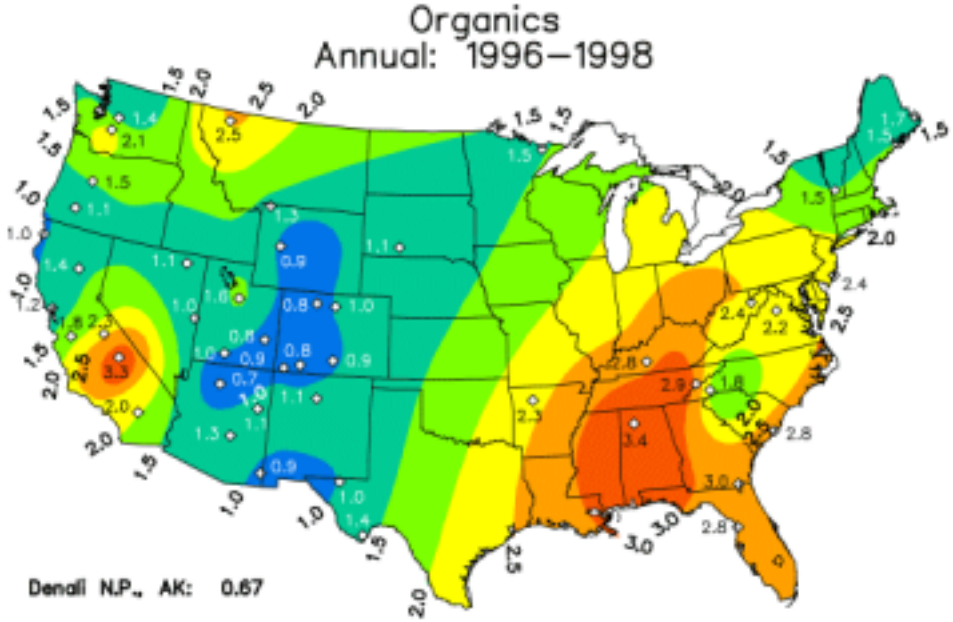


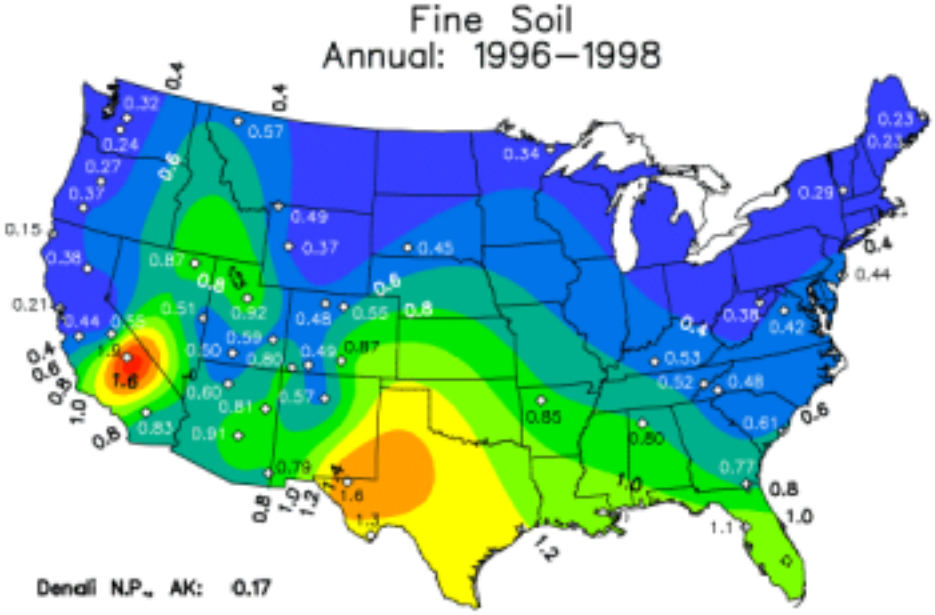
The IMPROVE reconstructed b_{ext} contains a number of assumption, however, overall it seems to work

Aerosol Spatial Patterns 1996-1998

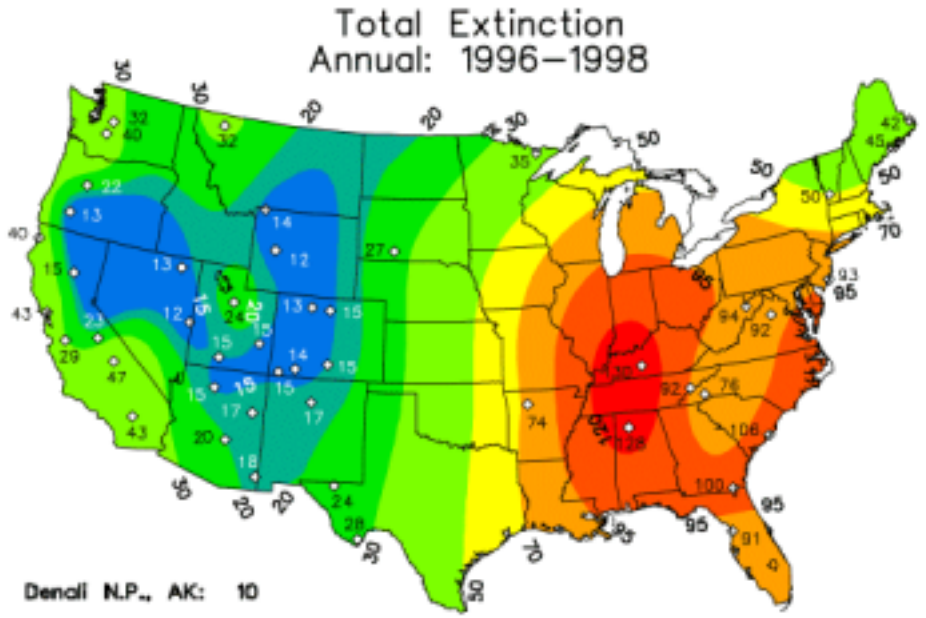


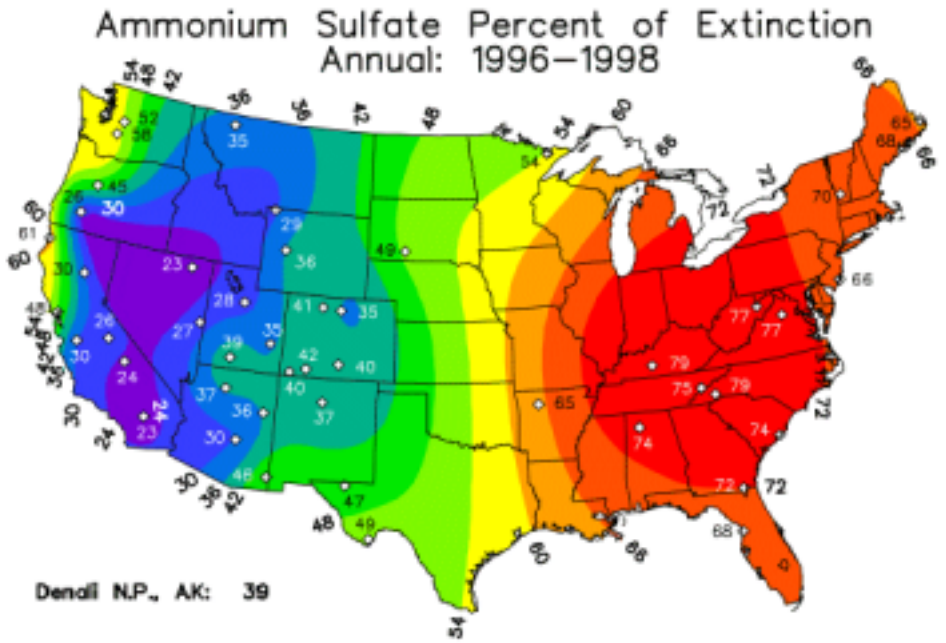


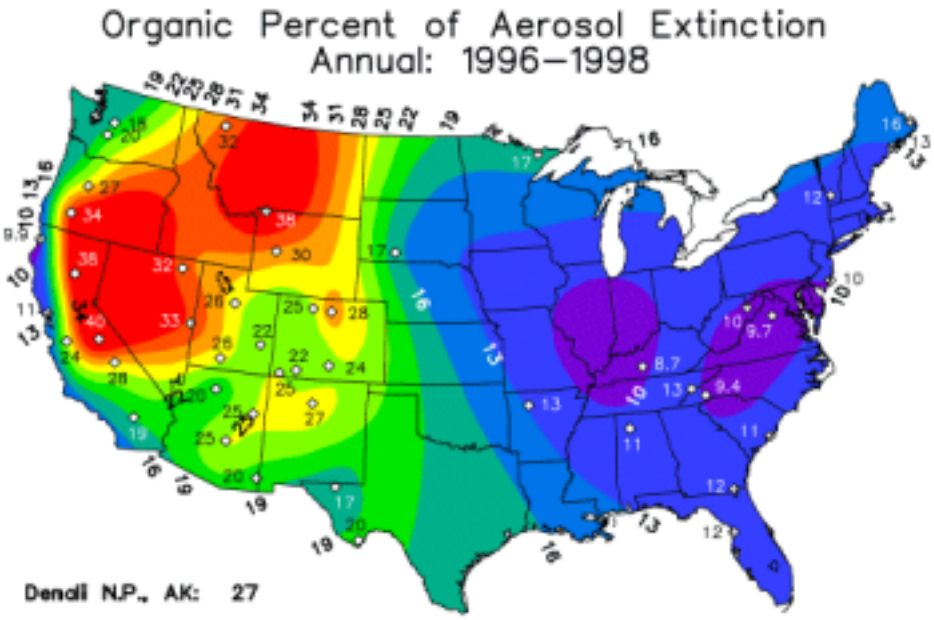


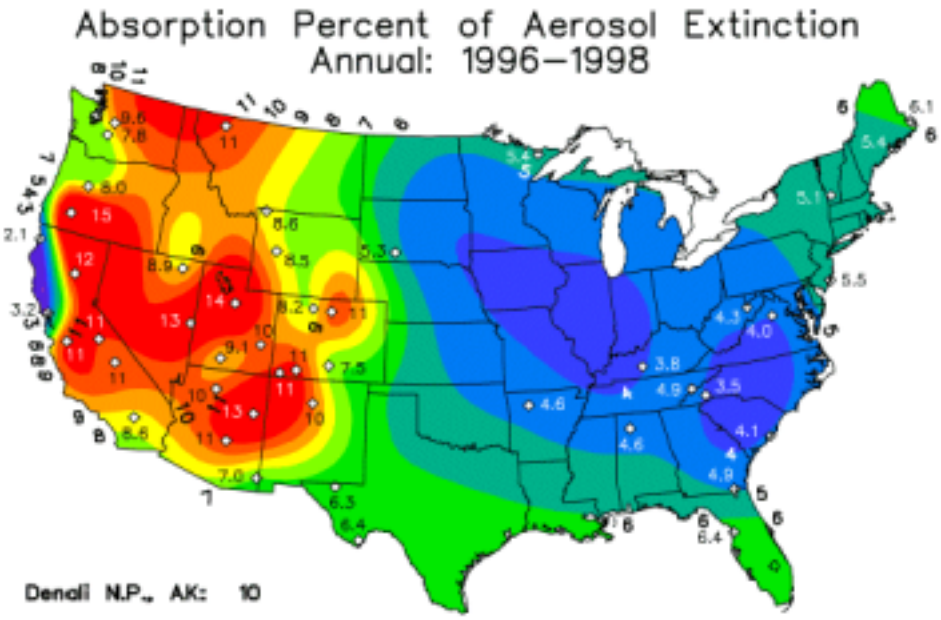


Reconstructed B_{ext} Spatial Patterns 1996-98

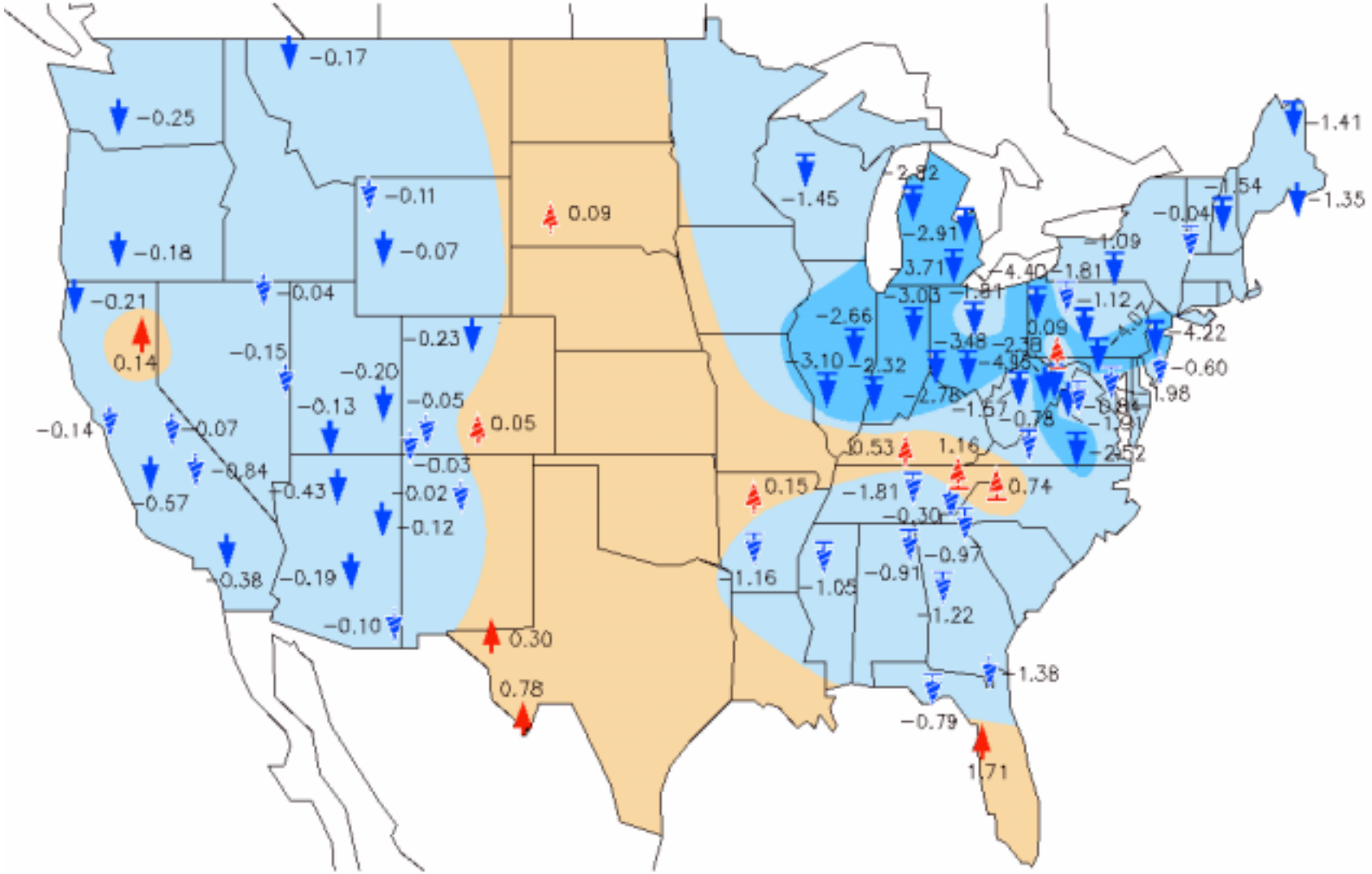






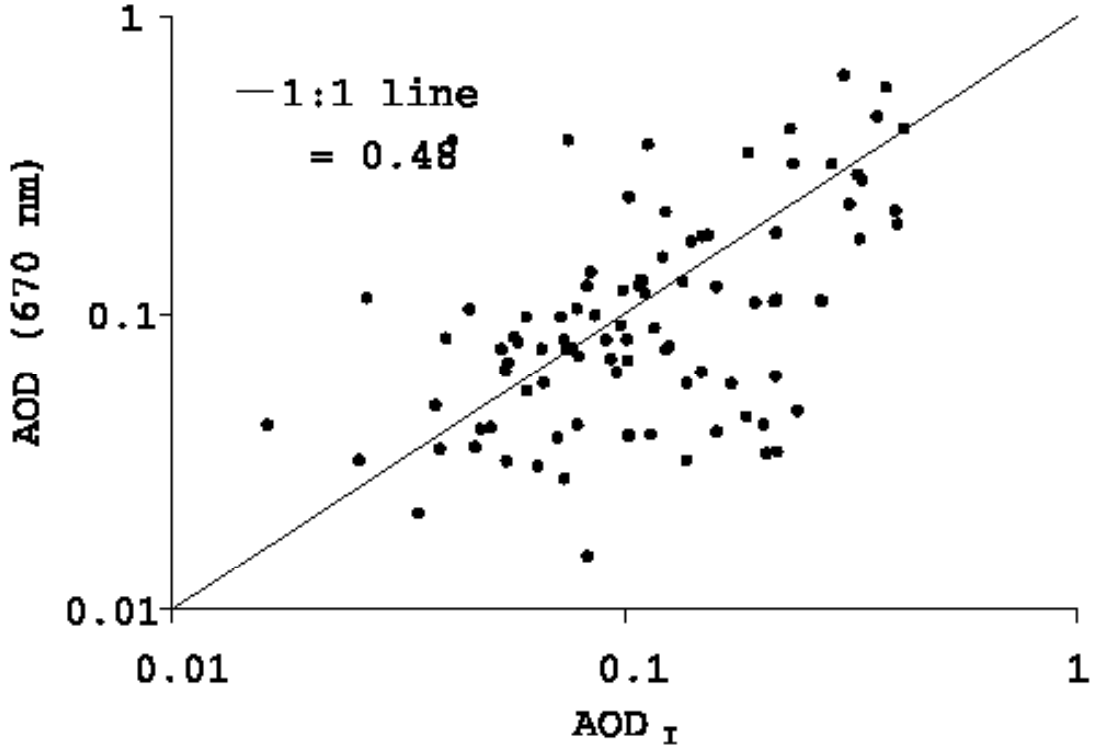


Sulfate Trends on the Worst 20% Days



Malm and Ames 2001

IMPROVE Derived AOD Compared to Measured Values from 1995–1997 (Corbin *et al.*, 2002)



- AOD 670 nm – measured optical depth from the Aerosol Robotic Network (AERONET) instrument at Goddard Space Flight Center
- AOD_I - IMPROVE derived AOD at Washington, D.C. calculated by multiplying the reconstructed b_{ext} by the boundary layer dept at for the years 1995–1997.
- The data were screened for clouds.
- The correlation of the ranks is 0.55

Data Availability - IMPROVE Web Site

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

Purpose:

Describe, document, and delivery IMPROVE aerosol and optical data and data analysis products relevant to regional haze

Visibility Information Exchange Web System

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

National (United States) aerosol and optical data integration, analysis and delivery system supporting the better understanding and analysis of haze and the implementation of the U.S. Regional Haze Regulation

Designed to acquire, manage, and provide access to data and metadata from multiple monitoring networks in a uniform format

VIEWS Data Inventory

Data Sets currently available from VIEWS:

Network	Parameters	Location (sites)	Time
ARS	Light Scattering and extinction	United States (17)	1988 – present
CASTNET	Speciation aerosol data	United States: (120)	1987 – present
EPA AIRS FRM	Fine mass (<2.5 microns)	United States: (1500)	1999 – present
EPA AIRS Speciation	Speciation aerosol data	United States: (200)	1999 – present
IMPROVE	Speciation aerosol data, Light Scattering and extinction	United States: (160)	1988 – present
MOHAVE	Speciation aerosol data, Light Scattering and extinction	Southwestern US. (40)	1992
PREVENT	Speciation aerosol data	Northwestern US: (30)	1990
REVEAL	Speciation aerosol data	British Columbia, CA (2)	1994-5
SEAVS	Speciation aerosol data, Light Scattering and extinction	Southeastern US: (1)	1995

Data Sets soon to be added to VIEWS:

Network	Parameters	Location	Time
National Park Service Stack Filter Units (SFU)	Speciation aerosol data	United States	1976-1988
NESCAUM	Speciation aerosol data	Northeastern US	1988-1993
BRAVO	Speciation aerosol, light scattering and extinction	Texas	Summer 1999
SEARCH	speciated aerosol, gaseous, surface met	Southeastern US	1998-present
National Park Service Gas	Gaseous species	United States	19?? - present
GAViM	PM2.5, speciated aerosol	Canada	1994 - present

Guide to Resources

- to query the aerosol database:
  http://vista.cira.colostate.edu/improve/Data/DataQuery/IMP_Aer_Data_Acc
- to download predefined aerosol ASCII files:
  http://vista.cira.colostate.edu/improve/Data/IMPROVE/IMPLocTable_Data.asp
- to download nephelometer and transmissometer ASCII files at:
  http://vista.cira.colostate.edu/improve/Data/IMPROVE/Data_IMPOptical.asp
- to get a full description of all of the IMPROVE sites:
  http://vista.cira.colostate.edu/improve/Data/GraphicViewer/metadata.asp
- new “VIEWS” website at (aerosol/haze integration effort):
  http://vista.cira.colostate.edu/views/
- to get speciated data from IMPROVE, CASTNet EPA, AIRS …
  http://vista.cira.colostate.edu/views/Data/DataQuery/IMP_Aer_Data_Acces
- to see the metadata at:
  http://vista.cira.colostate.edu/views/Data/GraphicViewer/metadata.asp