

# **IMPROVE Aerosol Monitoring Network**

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# 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 provide 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 3<sup>rd</sup> 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



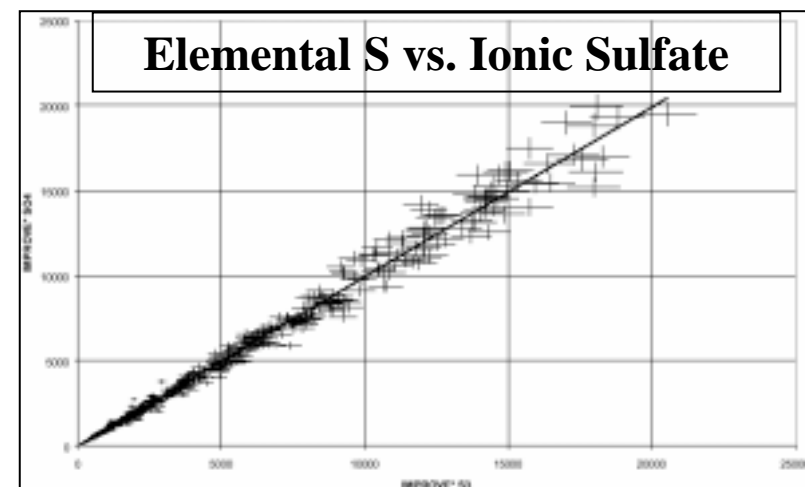
# IMPROVE Network Regions



- 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
  - $B_{\text{abs}}$  vs. LAC
  - OMC vs. OMH
  - $\text{PM}_{2.5}$  mass vs.  $\text{PM}_{10}$  mass
  - Reconstructed mass vs. mass

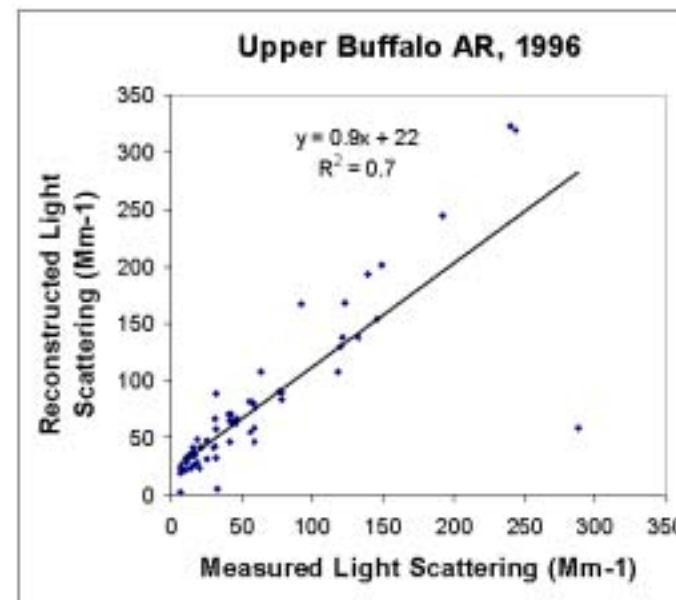
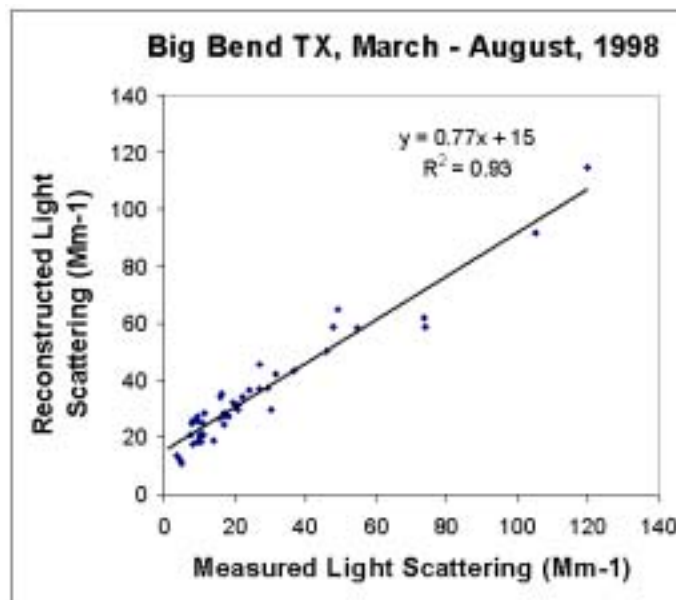


# IMPROVE aerosol data are used to estimate haze ( $b_{ext}$ ) in class I areas (rural United States)

Reconstructed light extinction equation:

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

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



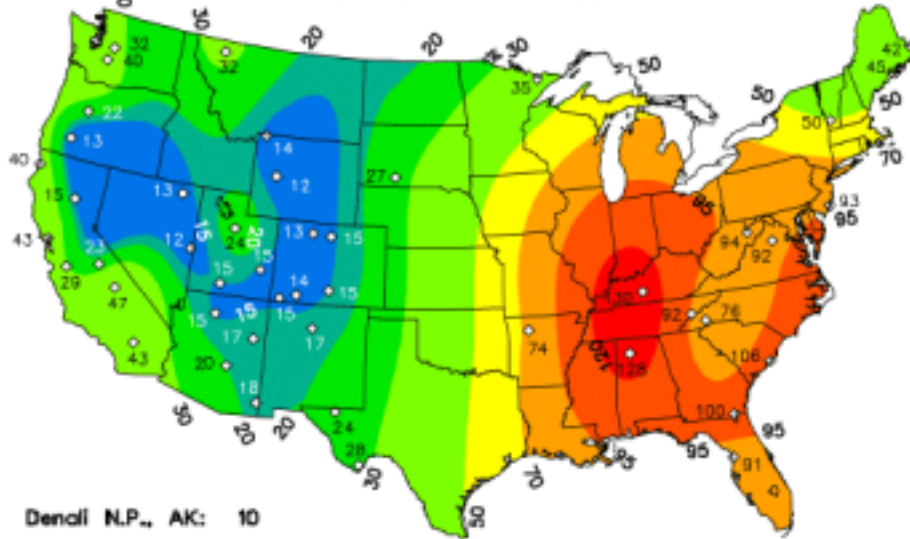
The IMPROVE reconstructed  $b_{ext}$  contains a number of assumption, however, overall it seems to work



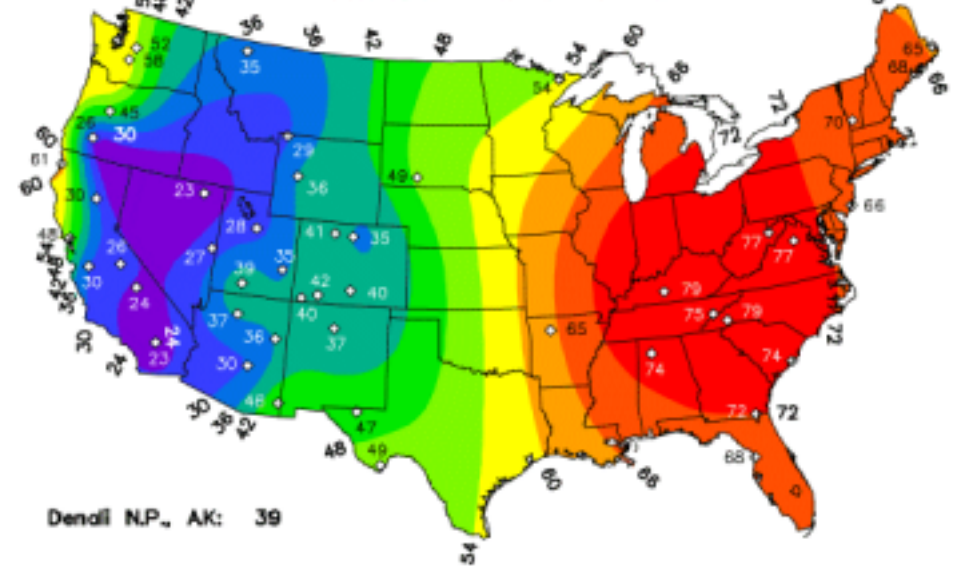


# Reconstructed $B_{ext}$ Spatial Patterns 1996-98

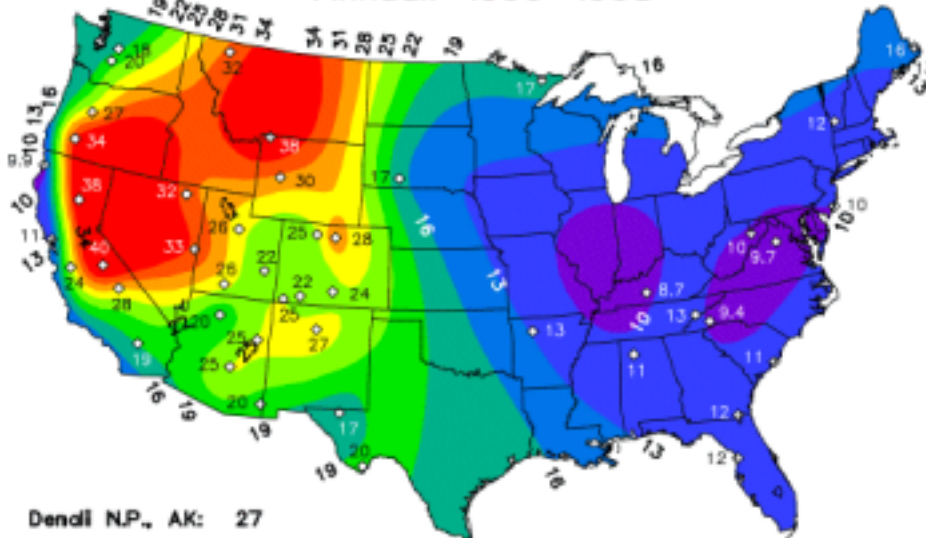
Total Extinction  
Annual: 1996-1998



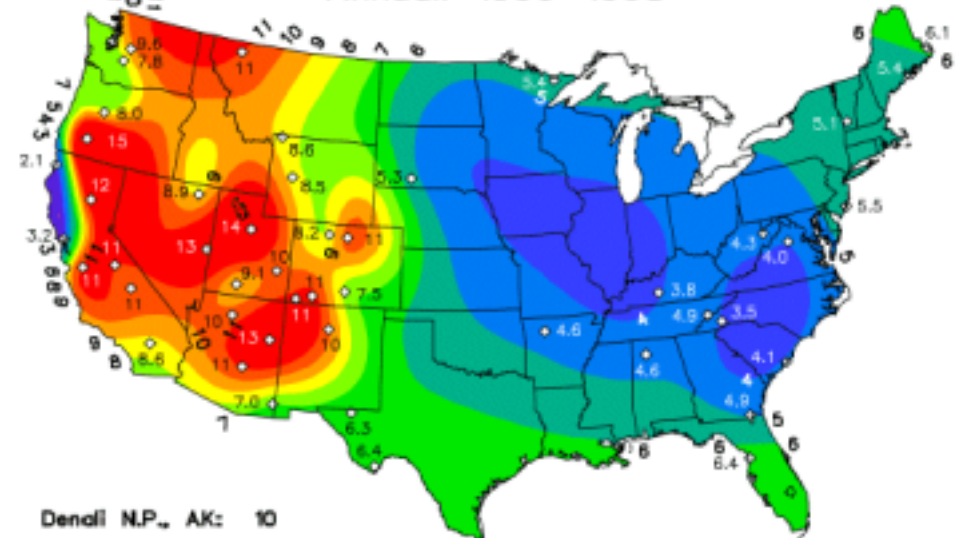
Ammonium Sulfate Percent of Extinction  
Annual: 1996-1998



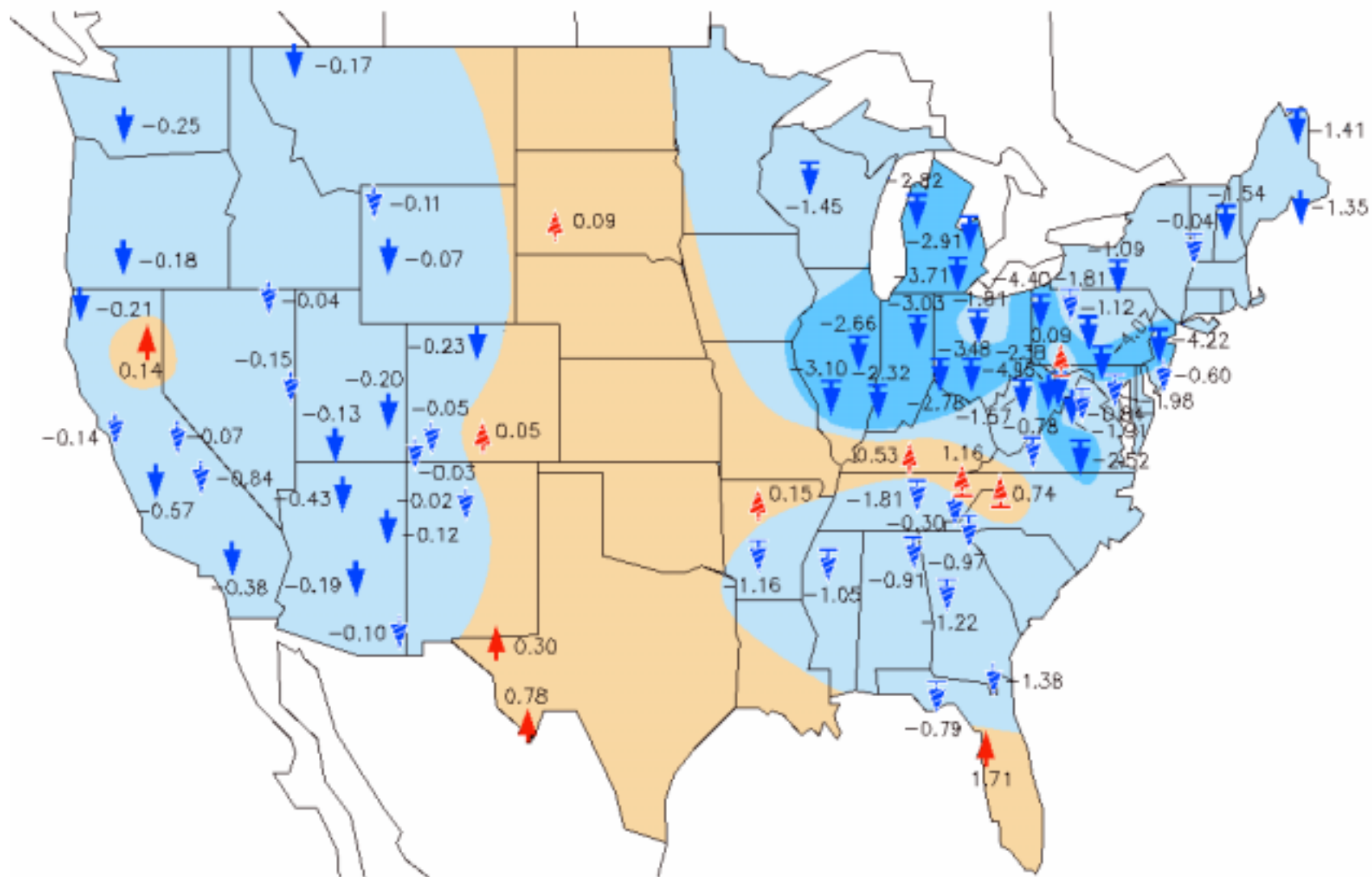
Organic Percent of Aerosol Extinction  
Annual: 1996-1998



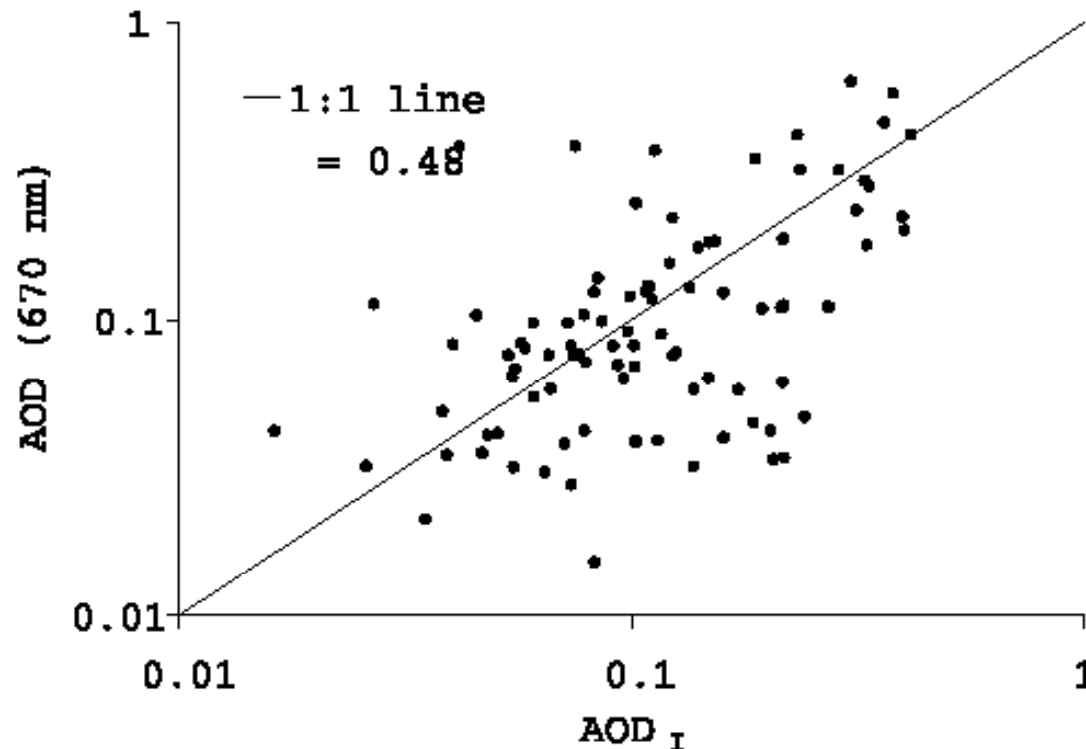
Absorption Percent of Aerosol Extinction  
Annual: 1996-1998



# Sulfate Trends on the Worst 20% Days



# 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<sub>I</sub> - IMPROVE derived AOD at Washington, D.C. calculated by multiplying the reconstructed  $b_{\text{ext}}$  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

**IMPROVE** Interagency Monitoring of Protected Visual Environments

Home Search Contents Contact

Overview Data Tools Publications Studies Education/Pag Forum Activities Links

## Interagency Monitoring of Protected Visual Environments

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 causal mechanism for the visibility impairment in the National Parks and Wilderness Areas.

The purpose of this website is to provide access to the IMPROVE monitoring data resources and educational material on the science of visibility and regulations. First time visitors should visit the Overview section which summarizes the IMPROVE network and visibility science and regulations.

$B_{ext}$ ( $Mm^{-1}$ )	20	30	40	60	100	200	300	500		
Dist (Miles)	4	7	11	14	18	23	30	34	37	39
V.R. (km)	200	130	100	65	40	20	11	10	8	

IMPROVE and Visibility Overview

Data Resources Tools Publications Special Studies Visibility & Regulation Education

### IMPROVE Resources

Database Metadata Graphics Photos Web Cams IMPROVE Reports Grey Literature

### Bulletins

◆ Draft versions of the Regional Haze Guidance Documents are now available.

## Purpose:

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

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

# Visibility Information Exchange Web System

**VIEWS**  
Visibility Information Exchange Web System

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

**DATA**

- All Data
- Metadata
- Green Wizard
- ASCII Data File

**ANNUAL SUMMARY**

- Spatial Patterns
- Competition
- Trends
- Risk Transience
- Summary Data
- Archived Graphs

**CATALOGS**

- Air Quality Catalog
- Weather Catalog
- Emissions Catalog

**IMAGERY**

- Visibility Photos
- Class I Webcams
- Fixed Sensor

Question List

For best results, please use:  
Internet Explorer 5 (or higher)  
Netscape 6 (or higher)  
[more info...](#)

**Dedicated to reducing Regional Haze in Class I Areas through the exchange of Data, Tools, and Ideas**

**VIEWS**  
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, VIEWS supports global efforts to better understand the effects of air pollution on visibility and to improve air quality in general.

Database | Metadata | Summary | Catalogs | Photos | Webcams

**VIEWS Data**  
The VIEWS 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 VIEWS logo to to download the logo in various formats and sizes.

**VIEWS BULLETINS AND NEWS**

- All Bulletins and News

**New Presentation**

- [VIEWS Presentation at the 2003 AQS Conference](#)  
The presentation describes the nature, purpose, and overall design of the VIEWS system and provides an update on the current status of ongoing tasks as of April, 2003. Recently released features are explored, and various ideas for future development are presented.

**PARTNERS**

- EPA
- Midwest RPO
- VISTAS
- REGIONAL HAZE MANE-VU
- Environmental Protection Agency

**OF INTEREST**

- Visibility
- About Air Pollution
- Regional Haze Rule
- Class I Areas
- MPN/VS Program
- RPO Information
- Software Tools
- Our Staff
- Fire & Air Presentations

**NEWSLETTER**  
Signup for the VIEWS newsletter to receive bulletins and updates periodically by email.

**FEEDBACK**

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

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



# VIEWS Data Inventory

Data Sets currently available from VIEWS:

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

Data Sets soon to be added to VIEWS:

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