INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

Winter 2000 | The IMPROVE Newsletter | Volume 9 / Number 1

Monitoring update

Network operation status

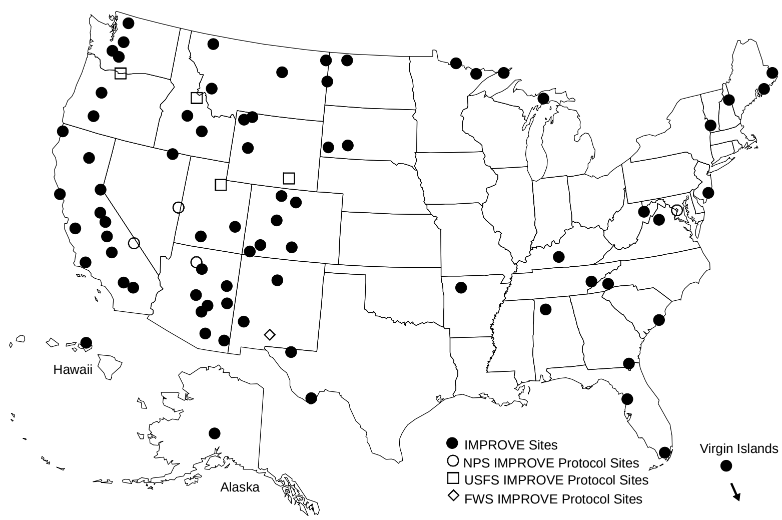
The IMPROVE network operated 73 aerosol samplers, 17 transmissometers, 8 nephelometers, and 6 camera systems during the Winter 2000 monitoring season (December 1999 and January and February 2000).

Preliminary data collection statistics for the Winter 2000 season are:

- Aerosol 89% collection
- Optical (transmissometer) 96% collection
- Optical (nephelometer) 97% collection
- Scene (photographic) 88% collection

As of February 29, 2000, 34 of the new aerosol samplers have been installed. The following monitoring sites are now operating with the new, IMPROVE Version II aerosol sampler:

Badlands NP
Bliss SP
Boundary Waters W
Bridger W
Death Valley NP
Denali NP
Dolly Sods W
Dome Land W
Gila W
Isle Royale NP
Joshua Tree NP
Kaiser W
Lostwood W
Medicine Lake W
Mount Rainier NP
Mount Zirkel W
North Absaroka W
North Cascades NP
Point Reyes NS
Rocky Mountain NP
San Rafael W
Seney W
Sequoia NP
Shenandoah NP
Sierra Ancha W
Snoqualmie NF
Theodore Roosevelt NP
U.L. Bend W
Voyageurs NP
White Pass
White River NF
Wind Cave NP
Yellowstone NP
Yosemite NP



IMPROVE and IMPROVE Protocol Sites
Winter 2000

Data availability status

Particulate data for all measurements including carbon are available through November 1999 on the UC-Davis FTP site. The seasonal summaries beginning with 1998 are available on http://improve.cnl.ucdavis.edu.

Optical data are available through May 1999 on the CIRA FTP site, at ftp://alta_vista.cira.colostate.edu.

Photographic slides are archived but are not routinely processed or reported. Complete photographic archives and slide spectrums (if completed) are available at ARS.

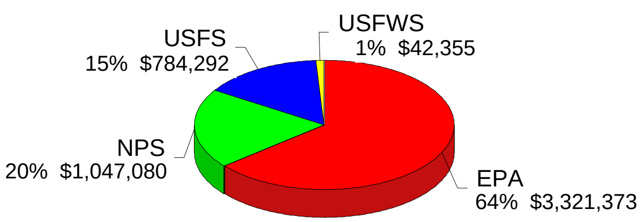
IMPROVE data are available to interested parties for use in presentations, management plans, and other projects. All data are validated using IMPROVE protocols, which are documented in standard operating procedures. Standard operating procedures are available for site selection; instrument installation, operation, and servicing; and data collection, reduction, validation, reporting, and archiving.

Visibility news

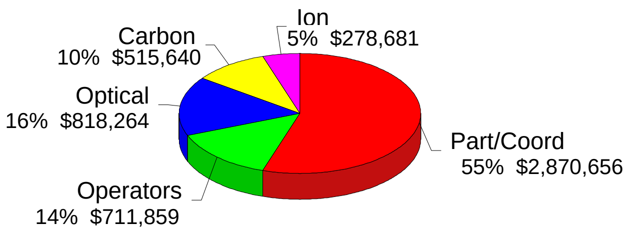
IMPROVE budget released for FY2000

The graphics below show anticipated funding contributions and distributions for operating the IMPROVE Program during Fiscal Year 2000.

IMPROVE Contributions by Agency



IMPROVE Costs by Component



For more information contact Mark Scruggs at the National Park Service Air Resources Division. Telephone: 303/969-2077. E-mail: mark_scruggs@nps.gov

IMPROVE committee meeting summary

The IMPROVE Steering Committee met in Las Vegas, Nevada, on February 8-9, 2000, to discuss the IMPROVE Program and review its operations. Major discussion topics included the status of the aerosol network expansion and various program accountability issues. The network expansion is behind schedule, but plans have been made to expedite the sampler installation process.

Accountability issues discussed included the need for an IMPROVE Web site where data and information specific to IMPROVE participants can be posted in one location. Preliminary plans are to include IMPROVE and IMPROVE Protocol data, the IMPROVE quality assurance program plan, a budget summary, standard data processing procedures, and other IMPROVE-specific information.

For more information contact Marc Pitchford at the U.S. EPA. Telephone: 702/895-0432. E-mail: marcp@snsc.dri.edu

What is an "IMPROVE Protocol" site?

The IMPROVE Steering Committee developed a definition of IMPROVE Protocol monitoring. Monitoring sites designated "IMPROVE Protocol" are sites that operate using standard, approved IMPROVE Program methods. Data from such sites are collected, analyzed, and reported consistently with all other IMPROVE and IMPROVE Protocol sites. Four factors (operation, duration, location, and data availability) define IMPROVE and IMPROVE Protocol sites:

Operation -

- Aerosol samplers must be sited following standard IMPROVE criteria.
- Aerosol samplers must contain all four filter modules ($PM_{2.5}$ Teflon, nylon, quartz, and PM_{10} Teflon).
- Aerosol sampler operation must follow the same sampling, handling, analytical, and quality assurance procedures used for IMPROVE sites.
- Aerosol samplers must follow the standard IMPROVE sampling frequency, without seasonal breaks. Daily sampling would be permitted, since it would include the standard IMPROVE sampling days as a subset.
- Optical sites must operate with an Optec LPV-2 transmissometer or an Optec NGN-2 nephelometer.
- The IMPROVE Program encourages camera monitoring systems at all sites.

Duration - The site must operate for at least one year.

Location - Any area may be considered IMPROVE Protocol, however, the IMPROVE aerosol sampler was designed to provide maximum sensitivity in comparatively pristine environments. IMPROVE is a non-urban network and monitors only in Class I areas. The appropriate network for urban sites is the EPA Speciation Network.

Data Availability - Data from IMPROVE and IMPROVE Protocol sites are available to the public.

The sole difference between IMPROVE and IMPROVE Protocol sites is the managing agency. While IMPROVE sites are the direct responsibility of the IMPROVE Steering Committee, IMPROVE Protocol sites may be operated by a Federal Land Manager, a state, or other entity.

For more information contact Marc Pitchford at the U.S. EPA. Telephone: 702/895-0432. E-mail: marcp@snsc.dri.edu

Aerosol sampler schedule to change

IMPROVE aerosol sampler operations are currently on a Wednesday-Saturday schedule and will change to a 1-day-in-3 schedule when all new samplers are installed at identified monitoring locations. The 1-day-in-3 schedule will require sample changing always on Tuesday. With this protocol, the arrangement of ambient filters will vary slightly each week, and the pattern will repeat every third week. The most important difference of the 1-day-in-3 protocol is that the sampler will be operating when the operator arrives to service the sampler every third week.

Instrument operators will see two main changes when servicing the instrument for sample changing: 1) they will read a controller screen rather than gauges, and 2) the filter cassettes will be preloaded into cartridges. Operator training on sampler operation and cassette changing is provided during sampler installation.

For more information contact Bob Eldred at UC-Davis. Telephone: 530/752-1124. E-mail: eldred@crocker.ucdavis.edu

Scene monitoring details visual conditions

Scene monitoring, or using camera systems to document visual scenes, is an important component of visibility monitoring. The IMPROVE Program encourages camera monitoring systems at all sites, but the decision to use cameras is at the discretion and funding ability of Federal Land Managers and/or states. As IMPROVE aerosol monitoring expands into more Class I areas, local Federal Land Managers and states may wish to consider sponsoring a camera system to document the range of visibility impairment at the sites. Using actual images of visibility conditions at Class I areas is a useful method of communicating with the public, local officials, and agency managers, as visual images supplement quantitative data collected by aerosol or optical monitors.

Scene monitoring relies on views with scenic features at various distances, to provide sufficient sensitivity in the view to various levels of visibility impairment. Finding appropriate views can be challenging in some locations. For example, in some Fish and Wildlife Service areas, distant features are not available for scenic views. In these areas, photographs of a distant artificial target can be used to document view impairment. IMPROVE standard operating procedures detailing scene site selection guidelines are available.

After about five years of scene monitoring, camera systems can be moved to new locations and slide spectrums can be created to document the range of visual conditions. The spectrums can be archived on CD-ROMs and used for a number of purposes.

AC-powered digital camera systems are currently being used at a number of sites and remote battery-powered systems are being developed. These battery-operated units will contain a reusable memory card, or “digital film” to store the photographic images. The US Forest Service plans to install six remote digital cameras systems at monitoring locations this year.

For more information contact Dan Ely at STAPPA/State of Colorado. Telephone: 303/692-3228.
E-mail: dwely@smtpgate.dphe.state.co.us

WinHaze software includes assorted sites for air quality modeling

Changing a photograph’s appearance to simulate visibility conditions for various air quality levels can be a clear and effective way of illustrating visibility changes. WinHaze, a Level-1 visual air quality model, is available as freeware for this purpose, at http://www.air-resource.com.

WinHaze allows the user to input different optical parameters or concentrations of aerosol species, to illustrate how these factors can affect the appearance of a scene using a desktop computer. WinHaze currently includes the following scenic locations for photographic simulation:

National Parks:
Acadia, ME
Big Bend, TX
Bryce Canyon, UT
Canyonlands, UT
Capitol Reef, UT
Chiricahua, AZ

National Parks:
Grand Canyon, AZ
Great Smoky Mountains., TN
Isle Royale, MI
Shenandoah, VA
Yosemite, CA

Wilderness Areas:
Bridger, WY
Dolly Sods, WV
Great Gulf, NH
James River Face, VA
Shining Rock, NC
West Elk, CO

Urban Scenes:
Boston, MA
Dallas, TX
Denver, CO
Fort Collins, CO
Phoenix, AZ
Tucson, AZ

Mount Zirkel Visibility Study:
Continental Divide Trail North to Mount Ethyl
Mount Zirkel to the Dome
Panorama From Davis Peak South to Mount Zirkel

Project MOHAVE:
Meadview
Red Mountain
Tuweep East
Tuweep West

For more information contact John Molenar at Air Resource Specialists, Inc. Telephone: 970/484-7941.
E-mail: jmolenar@air-resource.com

***Visibility news** continued on page 6*

Feature article

IMPROVE and NIOSH carbon measurement methods show differences

Introduction

IMPROVE has used the thermal/optical reflectance (TOR) method to quantify carbon concentrations on more than 100,000 separate $PM_{2.5}$ and PM_{10} samples in a variety of air quality studies. Eight separate carbon fractions, defined by temperature, oxidation atmosphere, and helium-neon laser light reflectance, are included in the IMPROVE database. These fractions are commonly summed into two components related to light absorbing (elemental carbon or EC) and non-absorbing (organic carbon or OC) particles. The sum is total carbon (TC).

An interim carbon analysis developed by the National Institute of Occupational Safety and Health (NIOSH) for elemental carbon in diesel exhaust is being considered by the U.S. EPA for application in the national $PM_{2.5}$ speciation network. The IMPROVE TOR and NIOSH thermal/optical transmission (TOT) methods are similar in concept, but differ with respect to evolution temperatures and optical pyrolysis adjustments. Dr. Judith Chow of the Desert Research Institute presented a paper at the PM2000 specialty conference (January 28-30, 2000, in Charleston, SC) that compared the IMPROVE and NIOSH methods applied to the same sixty samples. These samples were from urban and non-urban locations as well as source effluents and included previously analyzed samples from the IMPROVE network. The experiment showed that TC concentrations were similar between the two methods, but that NIOSH EC concentrations were less than half of those determined by the IMPROVE method.

Measurement Methods

Total ambient atmospheric carbon concentrations are typically measured by collecting ambient particles on a filter and subsequently heating the filter to volatilize or oxidize the deposit into a gas. The carbon in the gas stream is converted to carbon dioxide or methane for quantitative detection. The IMPROVE and NIOSH carbon analysis methods have similarities and differences related to temperature, residence time, optical monitoring, and combustion atmosphere.

Figures 1 and 2 show the temperature, laser reflectance, laser transmittance, and combustion atmosphere for the IMPROVE and NIOSH methods applied in this study.

Temperature and Residence Time

Temperature programs differ with respect to the set-points, residence times at each set-point, and rate of temperature change between set-points. As shown in Figure 1, the temperature set-points for the IMPROVE method are 120°C, 250°C, 450°C, and 550°C in a non-oxidizing pure helium atmosphere, and 550°C, 700°C, and 800°C in an oxidizing atmosphere of 2% oxygen/98% helium. The NIOSH temperature set-points in Figure 2 are 250°C, 500°C, 650°C, and 850°C, in pure helium, and 650°C, 750°C, and 850°C, in a 10% oxygen/90% helium atmosphere.

The residence time at each set-point is longer for IMPROVE than for NIOSH analysis. The IMPROVE residence times differ for each sample, sufficient for each carbon peak to be well-defined. Change to the next set-point is not initiated until the slope of the flame ionization detection (FID) response approaches zero. NIOSH (1996) does not explicitly specify residence times at the temperature set-points. Well-defined carbon fractions were found when NIOSH residence times in the helium atmosphere were at 150 seconds for the 250°C, 500°C, 650°C, set-points, and at 160 seconds for the 850°C set-point. After the oxygen was added, residence times were 150 seconds each at 650°C, 750°C, and 850°C.

Optical Monitoring

Light reflectance and transmittance are measured to determine the color change of the filter throughout the analysis. The filter deposit darkens when temperature increases in the helium atmosphere owing to pyrolysis of organic carbon compounds to elemental carbon. Optical measurements determine when average reflectance or transmittance attains the value it had when the sample was inserted into the analyzer, with the carbon evolved after this value defined as light-absorbing carbon.

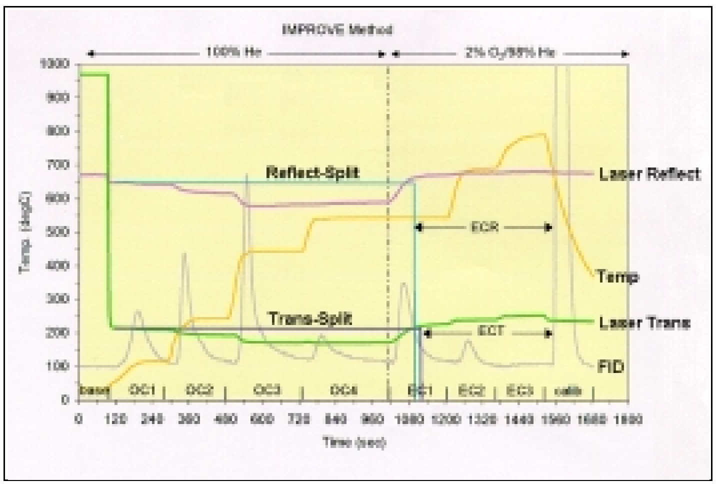


Figure 1. IMPROVE-method carbon thermogram for sample collected at Jarbidge Wilderness, Nevada, on May 26, 1999.

Light-absorbing carbon may differ from what some researchers consider to be elemental carbon because there are some heavy organic materials that absorb light. Neither reflectance nor transmittance is a true measure of particle light absorption in these methods, since no accounting is made for losses due to scattering by the quartz-fiber filter or particle deposit.

As seen in Figures 1 and 2, both reflectance and transmittance decrease with increasing temperature in an oxygen-free environment, at temperatures up to 650°C. The transmittance in both methods shows some interference from the glowing oven when current is first applied to raise temperatures above 500°C, but this does not affect the point at which it returns to its original value.

Figures 1 and 2 also show that the reflectance achieves its original value about 22 seconds earlier than the transmittance achieves its original value. The difference in optical monitoring for pyrolysis is an important difference between the IMPROVE and NIOSH methods.

Combustion Atmosphere

Oxygen is added to the helium atmosphere after organic carbon evolves from the sample. The IMPROVE method adds a 2% oxygen/98% helium mixture, while NIOSH adds a 10% oxygen/90% helium mixture. Both of these mixtures supply sufficient excess oxygen to fully combust elemental carbon and the difference between the two methods is believed to be unimportant.

Conclusions

The IMPROVE and NIOSH thermal/optical carbon analysis methods are equivalent for total carbon sampled on quartz-fiber filters. For IMPROVE samples, the total, organic, and elemental carbon fractions were similar to the original measurements made up to 30 months prior to this experiment. This indicates that IMPROVE sample storage procedures preserve carbonaceous components for future analyses.

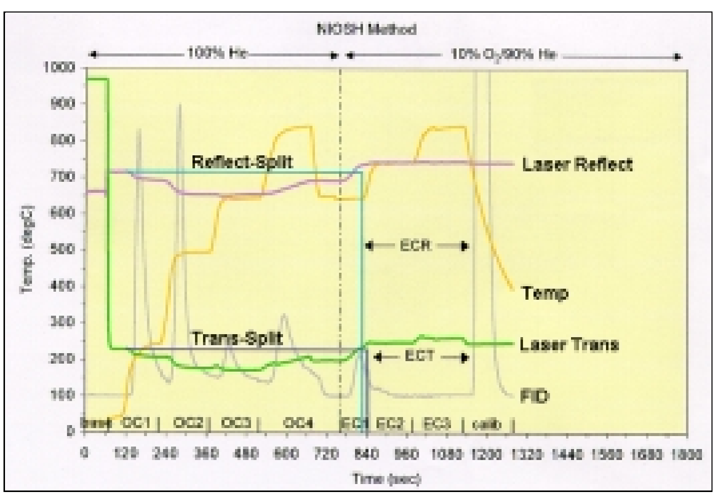


Figure 2. NIOSH-method carbon thermogram for sample collected at Jarbidge Wilderness, Nevada, on May 26, 1999.

NIOSH elemental carbon was typically less than half of IMPROVE elemental carbon. The primary difference between sub-fractions determined by these methods is the allocation of carbon evolving at the NIOSH 850°C temperature in a helium atmosphere to the organic rather than elemental carbon fraction. When this portion of organic carbon is added to NIOSH elemental carbon, the IMPROVE and NIOSH analyses are in good agreement. Helium-neon laser reflectance and transmittance monitored during the NIOSH analyses increased during the 850°C period, indicating that light-absorbing carbon was being released and measured as organic carbon.

For both methods, the pyrolysis adjustment to the elemental carbon fractions was always higher for transmittance than for reflectance. This is a secondary cause of differences between the two methods, with transmittance resulting in a lower elemental carbon loading than reflectance. The difference was most pronounced for very black filters on which neither reflectance nor transmittance was able to accurately detect further blackening due to pyrolysis.

This experiment concluded with three recommendations: 1) traceable carbon standards for carbon and optical calibrations are needed, 2) well-defined fractions should continue to be reported so organic carbon and elemental carbon can be reconstructed for comparison in extinction calculations, and 3) pyrolysis carbon should be reported by reflectance and transmission methods to allow for evaluation of bias of optical correction.

Future NIOSH carbon analyses for the $PM_{2.5}$ speciation network should report a well-defined carbon concentration that evolves at 850°C, as well as the amount of carbon that evolves after transmittance returns to its initial value. The IMPROVE method should continue to report its well-defined fractions to maintain consistency with measurements taken since 1987, but it should also report carbon fractions that evolve after transmittance, as well as reflectance, achieves its original concentrations for comparability with the NIOSH procedure.

For more information on this experiment, download the following article or contact Dr. Judith Chow at the Desert Research Institute. Telephone: 775/674-7050. E-mail: judyc@dri.edu

"Method 5040 Issue 3 (Interim) Elemental carbon (diesel particulate)" at http://www.cdc.gov/niosh/pdfs/5040.pdf

Visibility news *continued from page 3....*

Photographic spectrum development

Photographs or digital images can be useful in presenting technical air quality information. Slide spectrums are being created for IMPROVE monitoring sites that have over five years of slides in their archives. The spectrums, selected from the 35 mm slide visibility database and archived on CD-ROM, contain slides that illustrate the range of visual conditions at each site, cumulative frequency summaries, selected episodes, and site specifications.

The following monitoring locations have spectrums completed or are scheduled to have spectrums developed:

COMPLETED:

Acadia NP
Badlands NP
Bandelier NM
Big Bend NP
Bridger W
Bryce Canyon NP
Canyonlands NP
Chiricahua NM
Glacier NP
Grand Canyon NP
Great Smoky Mountains NP
Guadalupe Mountains NP
Jarbidge W
Mesa Verde NP
Rocky Mountain NP
Shenandoah NP
Yellowstone NP

SCHEDULED:

Boundary Waters Canoe Area W
Cape Romain NWR
Chassahowitzka NWR
Crater Lake NP
Denali NP
Dolly Sods W
Edwin B. Forsythe NWR
Everglades NP
Great Basin NP
Great Sand Dunes NM
Haleakala NP
Hawaii Volcanoes NP
Lassen Volcanic NP
Lye Brook W
Mammoth Cave NP
Mount Rainier NP
Okefenokee NWR
Petrified Forest NP
Pinnacles NM
Point Reyes NS
Redwood NP
San Gorgonio W
Tonto NM
Voyageurs NP
Weminuche W
Yosemite NP

See *IMPROVE Newsletter*, Volume 7, No. 3 (Summer 1998) for a discussion on the creation and contents of slide spectrums.

For more information contact Dee Morse at the National Park Service. Telephone: 303/969-2817. E-mail: dee_morse@nps.gov

Using slide spectrums to compare data

The saying "a picture is worth a thousand words" can be applied to slide spectrums. Spectrums can be used to convey visual air quality information to laypersons, or to provide a visual means of comparing quantitative data. Figure 1, an example spectrum of Bryce Canyon National Park, Utah, shows three levels of visual air quality. The dominant background feature, Navajo Mountain, fades from view as visibility worsens. These photographs may be presented along with corresponding aerosol or optical data to visually explain varying air quality levels.

Figure 1. Three levels of visual air quality at Bryce Canyon National Park, Utah, documented in a slide spectrum.
a) The top photograph shows a "good" visibility day. Navajo Mountain is visible in the background.
b) The middle photograph shows a "medium" visibility day. Navajo Mountain is faintly visible and color and sharpness of foreground features become faded.
c) The bottom photograph shows a "poor" visibility day. Navajo Mountain disappears from view and foreground features become difficult to discern.

For more information about slide spectrums contact Dee Morse at the National Park Service. Telephone: 303/969-2817. E-mail: dee_morse@nps.gov

IMPROVE aerosol data concur with optical data in northeast haze episode evaluation

IMPROVE nephelometer data, along with other "quickly available" continuous measurements were presented in the October 1999 *IMPROVE Newsletter* to illustrate an exceptionally hazy episode that affected New England and Southeastern Canada during mid-July of last summer. IMPROVE aerosol data for this time period have recently become available, and provide additional insights into the extreme nature of this haze event.

Figure 1 shows fine particle mass composition for selected sites along or near the New England coast on July 17, 1999. The New Haven and Westport, CT sites, operated by the State of Connecticut, are urban and suburban sites that employed IMPROVE samplers as part of a special study during the past two years. Ammonium sulfate accounts for about 2/3 of the fine particle mass, with concentrations generally increasing from New Jersey to the northeast along the Atlantic coast. This gradient is opposite to the usual summer aerosol pattern, which typically declines toward the northeast in this region. The fine mass and sulfate concentrations were the second highest ever recorded at Lye Brook, VT (since 1991) and the highest ever recorded at Acadia National Park (since 1988).

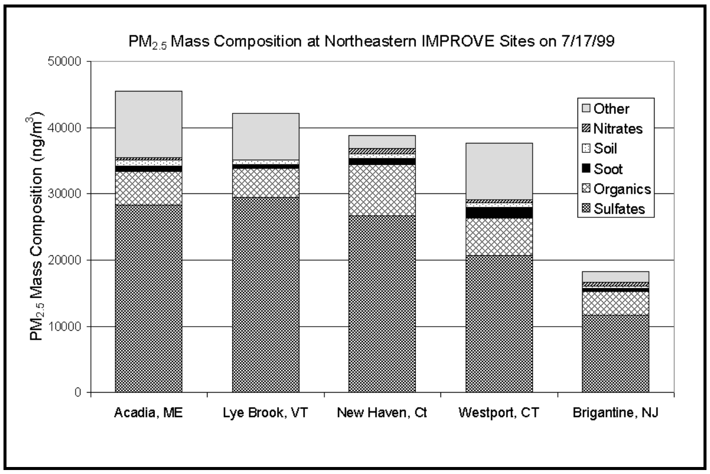


Figure 1. Fine particle mass composition near the New England coast on July 17, 1999.

Figure 2 shows the long-term daily and average sulfate levels for Acadia (expressed as ammonium sulfate). A 100-sample moving average sulfate concentration (an averaging time of about 1 year) indicates a generally downward trend in average sulfate levels over time for Acadia. However, there does not appear to be a similar improvement in the magnitude of worst case short-term concentrations, and the July 17, 1999 sulfate level of nearly 30 micrograms per cubic meter is 40% higher than the worst episodes recorded over the past 12 years.

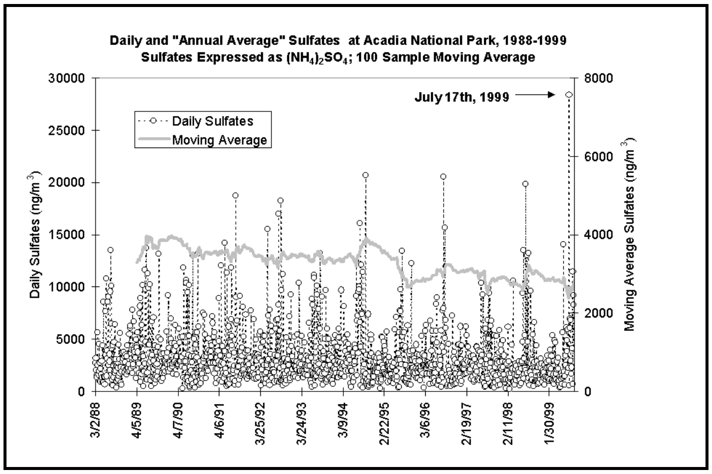


Figure 2. Long-term daily and average sulfate levels for Acadia.

For more information contact Rich Poirot at the Vermont Dept. of Environmental Conservation. Telephone: 802/241-3807. E-mail: richpo@dec.anr.state.vt.us

"Introduction to Visibility" available again

Demand for *Introduction to Visibility*, the 68-page booklet released last summer, quickly drained the available supply. The booklet, soon to be available again, explains the basic concepts of visibility including the nature of light, interaction of light and particles, transport and transformation of particles, measuring visibility, visibility trends, and more.

To receive a free copy, contact the National Park Service. Telephone: 970/491-8292. E-mail: burke@cira.colostate.edu

Special studies

Southeastern Aerosol and Visibility Study (SEAVS) report now available

A CIRA report will soon be available for the Southeastern Aerosol and Visibility Study (SEAVS). The study, performed during the summer of 1995 at Great Smoky Mountains National Park, Tennessee, was a partnership of electric utilities, the National Park Service, the Electric Power Research Institute, universities, and consulting firms. Researchers intended to fill gaps in the knowledge of atmospheric fine particle characteristics and visibility under humid conditions typical of the southeastern United States, and to produce reliable models to simulate the formation of these aerosols and their optical properties.

To receive a copy of the report, contact the National Park Service. Telephone: 970/491-8292. E-mail: burke@cira.colostate.edu

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IMPROVE STEERING COMMITTEE

IMPROVE Steering Committee members represent their respective agencies and meet periodically to establish and evaluate program goals and actions. IMPROVE-related questions within agencies should be directed to the agency's Steering Committee representative. Steering Committee representatives are:

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ASSOCIATE MEMBERS

Associate Membership in the IMPROVE Steering Committee is designed to foster additional IMPROVE-comparable visibility monitoring that will aid in understanding Class I area visibility, without upsetting the balance of organizational interests obtained by the steering committee participants. Associate Member representatives are:

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E-mail: moore.tom@ev.state.az.us

Government organizations interested in becoming Associate Members may contact any Steering Committee member for information.

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The IMPROVE Program was designed in response to the visibility provisions of the Clean Air Act of 1977, which affords visibility protection to 156 federal Class I areas. The program objectives are to provide data needed to: assess the impacts of new emission sources, identify existing human-made visibility impairments, and assess progress toward the national visibility goals as established by Congress.

To submit an article, to receive the IMPROVE Newsletter, or for address corrections, contact:

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IMPROVE Newsletters are also available on the National Park Service Web site at: http://www.nature.nps.gov/ard/impr/index.htm

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