INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

4th Quarter 2008 | The IMPROVE Newsletter | Volume 17 / Number 4

Feature Article: Aerosol generation system new tool for researchers, Page 4

Monitoring update

Network operation status

The IMPROVE (**I**nteragency **M**onitoring of **Pro**tected **V**isual **E**nvironments) Program consists of 110 aerosol visibility monitoring sites selected to provide regionally representative coverage and data for 155 Class I federally protected areas. Additional instrumentation that operates according to IMPROVE protocols in support of the program includes:

- 59 aerosol samplers
- 34 nephelometers
- 4 transmissometers
- 4 digital camera systems
- 58 Webcamera systems
- 5 interpretive displays

IMPROVE Program participants are listed on page 8. Federal land management agencies, states, tribes, regional air partnerships, and other agencies operate supporting instrumentation at monitoring sites as presented in the map below. Preliminary data collection statistics for the 4th Quarter 2008 (October, November, and December) are:

- Aerosol (channel A only) — 95% collection
- Aerosol (all modules) — 94% completeness
- Optical (nephelometer) — 96% collection
- Optical (transmissometer) — 88% collection
- Scene (photographic) (does not include Webcameras) — 87% collection

A new aerosol monitoring site was established at Gates of the Arctic National Park and Preserve, AK, in October, sponsored by the National Park Service. See page 2 for details.

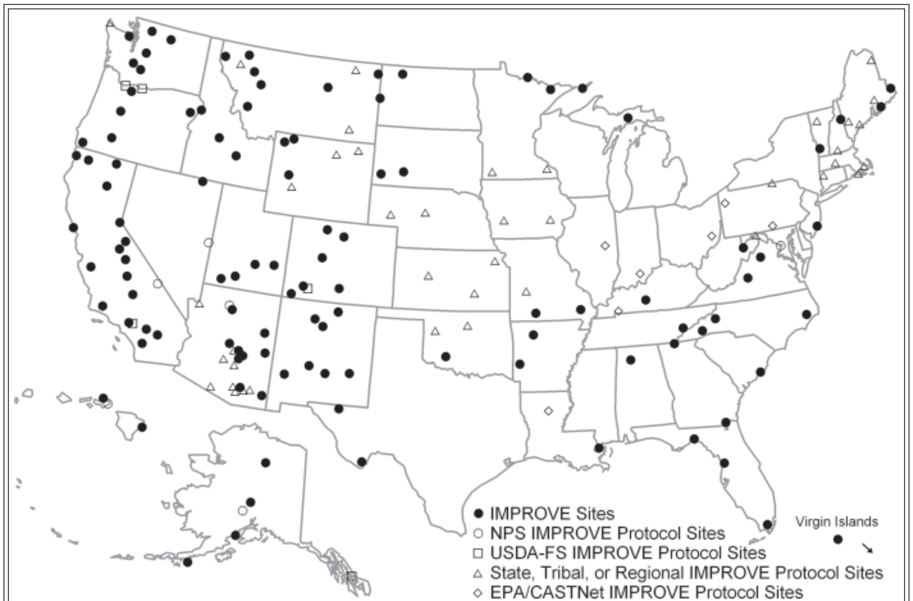
Data availability status

Data are available on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/Data/data.htm* and on the VIEWS Web site at *http://vista.cira.colostate.edu/views*. Aerosol data are available through December 2007. Nephelometer and transmissometer data are available through September 2008 and December 2007 respectively.

Photographic slide spectrums are available on the IMPROVE Web site under *Data*. Real-time Webcamera displays are available on agency-supported Web sites:

- National Park Service *http://www.nature.nps.gov/air/WebCams/index.htm*
- USDA-Forest Service *http://www.fsvisimages.com*
- CAMNET (Northeast Camera Network) *http://www.hazecam.net*
- Midwest Haze Camera Network *http://www.mwhazecam.net*
- Wyoming Visibility Network *http://www.wyvisnet.com*
- Phoenix, AZ, Visibility Network *http://www.phoenixvis.net*

The EPA AIRNow Web site *http://airnow.gov* includes many of these as well as additional visibility-related Webcameras. Click on View Other Visibility Webcams.



IMPROVE and IMPROVE Protocol Sites
4th Quarter 2008

Monitoring update continued on page 3....

Visibility news

Gates of the Arctic National Park and Preserve joins IMPROVE network

A new IMPROVE Protocol site was established in late October 2008 to represent air quality at Gates of the Arctic National Park in north central Alaska. The site is located at Bettles, Alaska, north of the Arctic Circle. The code designation for this new site is GAAR1, and the first samples were collected on November 4, 2008.

The sampler is housed in a shelter to provide protection from the harsh Alaskan winters. The shelter has two small rooms. One room contains the sampler modules and is kept near ambient temperature to maintain sample integrity. The other room is insulated, houses the controller, and can be heated to provide comfort for the operator. The site is operated by Rachel and Max Hanft, local Bettles residents.

The Gates of the Arctic sampler was installed by Jose Mojica of UC-Davis. The installation at this site presented challenges not encountered during most IMPROVE installations. Temperatures hovered around -17ºF on the days of installation, causing the glycerin-filled gauges to freeze and the electrical cables to turn brittle. Jose (who was tempered by Southern California winters) made the most of his situation and kept an optimal core temperature by wearing three days' worth of clothing under his snow gear, and by maintaining two personal heaters directed at him while working indoors. The thick clothing and little nuances, such as having to thaw most of the equipment with a personal hair dryer, made an installation that would normally have taken five hours turn into a two-and-a-half day adventure. Despite the small setbacks, the help provided by Andrea Blakesley of the National Park Service made the installation a success.

For more information contact Chuck McDade at the University of California-Davis. Telephone: 530/752-7119. Fax: 530/752-4107. E-mail: mcdade@crocker.ucdavis.edu.

Correction notice

The 3rd Quarter 2008 issue of this newsletter, delivered in December 2008, displays an error on page 4. All PM levels in the NAAQS table should read µg/m³. The microgram symbol did not print in the hardcopy version of the newsletter, but appeared as it should in the electronic version. Readers receiving the hardcopy version please note this error. The corrected table appears below.

Table 1. History of the PM National Ambient Air Quality Standard.

Final Rule	Indicator	Ave. Time	Level	Form
1971	TSP - Total Suspended Particles	24-hour	260 µg/m³ (primary) 150 µg/m³ (secondary)	Not to be exceeded more than once per year
		Annual	75 µg/m³ (primary)	Annual average
1987	PM_{10}	24-hour	150 µg/m³ *	Not to be exceeded more than once per year
		Annual	50 µg/m³	Annual average
1997	$PM_{2.5}$	24-hour	65 µg/m³	98th percentile
		Annual	15 µg/m³	Annual arithmetic mean, average over 3 years
	PM_{10}	24-hour	150 µg/m³	Initially promulgated 99th percentile form; when 1997 standards were vacated, form of 1987 standards remained in place (not to be exceeded more than once per year on average over a 3-year period)
		Annual	50 µg/m³	Annual arithmetic mean, average over 3 years
2006	$PM_{2.5}$	24-hour	35 µg/m³	98th percentile, average over 3 years
		Annual	15 µg/m³	Annual arithmetic mean, average over 3 years
	PM_{10}	24-hour	150 µg/m³	Not to be exceeded more than once per year on average over a 3-year period

* When not specified, primary and secondary standards are identical.

PUBLISHED BY:

Air Resource Specialists, Inc.

1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525

The IMPROVE Newsletter is published four times a year (February, May, August, and November) under National Park Service Contract C2350064025. To submit an article, to receive the IMPROVE Newsletter, or for address corrections, contact:

Gloria S. Mercer, Editor
Telephone: 970/484-7941 ext.221
Fax: 970/484-3423
E-mail: Gmercer@air-resource.com

IMPROVE Newsletters are also available on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/Publications/news_letters.htm.*

Publications and presentations

The following is a sampling of articles and presentations related to IMPROVE monitoring, published in 2008:

Archuleta, C. A., Adlhoch, J., and Copeland, S. A. 2008. IMPROVE data substitution methods for regional haze planning. Presented at the Air & Waste Management Association Visibility Specialty Conference, Moab, UT, April.

Ashbaugh, L.L., and Hyslop, N. P. 2008. New Methods for Quality Control, Data Validation, and Flagging of IMPROVE Data. Presented at the Air & Waste Management Association Visibility Specialty Conference, Moab, UT, April.

Hyslop, N. P., McDade, C.E., and White, W. H. 2008. Uncertainty in the IMPROVE Measurements. Presented at the Air & Waste Management Association Annual Conference, Portland, OR, June.

Hyslop, N. P., and White, W. H. 2008. Interagency Monitoring of Protected Visual Environments (IMPROVE) Detection Limits. Presented at the Air & Waste Management Association Visibility Specialty Conference, Moab, UT, April.

Hyslop, N. P., and White, W. H. 2008. Observed Precision in the IMPROVE Particle Monitoring Network. Presented at the Air & Waste Management Association Visibility Specialty Conference, Moab, UT, April.

McDade, C.E., White, W.H., and Dillner, A. M. 2008. Comparisons of Sulfur and Sulfate Measured in IMPROVE. Presented at the Air & Waste Management Association Visibility Specialty Conference, Moab, UT, April.

White, W. H. 2008. A Cabinet of Curiosities: IMPROVE's On-line Data Advisories. Presented at the Air & Waste Management Association Visibility Specialty Conference, Moab, UT, April.

Hyslop, N.P., and White, W.H. (2008) An evaluation of Interagency Monitoring of Protected Visual Environments (IMPROVE) collocated precision and uncertainty estimates. Atmospheric Environment, 42, 2691-2705.

White, W.H. (2008) Chemical markers for sea salt in IMPROVE aerosol data. Atmospheric Environment, 42, 261-274.

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

Monitoring update *continued from page 1 ....*

Operators of distinction

New York State participates in the IMPROVE Protocol aerosol monitoring network, by operating an urban site in the South Bronx NEYO1) and New York's operator, Richardson Colas, services the sampler.

Rich works for the New York State Department of Environmental Conservation (DEC) - Division of Air Resources. He was hired as Lab Equipment Designer in 1998 to help operate, maintain, and provide quality assurance for the state's extensive air monitoring network. He has operated the IMPROVE Protocol site in the South Bronx in New York City since 2005. "Our South Bronx site is one of the most extensive of the 80 ambient air monitoring sites in New York State operated by the DEC," said Rich. "In addition to the particulate monitoring, we also have a full suite of gaseous analyzers at the site to evaluate other EPA criteria air pollutants for state compliance with the National Ambient Air Quality Standards." The station is one of two National Air Toxics Trends sites in New York State, and is used by various state agencies and universities to perform health-related air quality studies.

Rich earned a B.S. degree in Electrical and Computer Engineering from the New York Institute of Technology. Before joining DEC, he had no prior experience in air quality monitoring, but the DEC provided excellent training. His engineering background also helped him catch on quickly and today he is responsible for instrument operation in numerous air monitoring networks and studies.

When not working, Rich loves to spend time and dine out with his wife, Joan, and one-year-old daughter, Siimone Celeste. One of their favorite foods is Thai. Rich also has a hobby of racing radio-controlled cars, and is involved with local organizations to better himself and others.

Rich is a native New Yorker and loves it. "I have a passion for this state," said Rich, "Helping our state environmentally through my work responsibilities allows me to exercise that passion."

The New York IMPROVE Protocol monitoring site, in South Bronx, is one of several monitoring sites maintained by Rich Colas.

***Monitoring update** continued on page 7....*

Feature article

Aerosol generation system developed as new tool for air quality researchers

(by C. McDade, Hege Indresand, and Ann Dillner, University of California - Davis)

Introduction

IMPROVE scientists at UC-Davis are developing a new aerosol generation system, designed to deposit samples of known composition on filters. These specially prepared samples will provide an independent tool to assess the calibration of the x-ray fluorescence (XRF) laboratory analysis method, and will allow investigation of cross-element interferences in the XRF spectra. The filters made by the aerosol generation system can also give information about detection limits (minimum of the range) and saturation effects (maximum of the range) of the XRF instrument.

This work is being conducted by Dr. Hege Indresand, a postdoctoral scholar at UC-Davis, along with her advisor, Dr. Ann M. Dillner. Crocker Nuclear Laboratory's machine shop has provided the needed custom equipment, manufactured to exact specifications.

Rationale

The need for the aerosol generation system emerged from questions about the calibration of the XRF system. Currently, calibration standards are purchased from a single vendor, and there are no alternative sources to provide an independent assessment. Furthermore, the elemental concentrations on the purchased standards are generally higher than those encountered in the IMPROVE network. XRF calibrations are performed at reduced instrument current to accommodate the high loadings on the standards, and then the actual field samples are analyzed at a higher current. Filter samples at lower concentrations (more representative of IMPROVE field samples) can be prepared using the aerosol generation system, so that XRF calibration checks can be performed under the same conditions as field sample analysis.

The commercially available standards are prepared on Mylar® or Nuclepore® substrates, not on Teflon® as used in routine IMPROVE sampling. Calibration samples prepared on Teflon® filters by the new aerosol generation system will better simulate the conditions of IMPROVE sample collection. Not only are the samples prepared on Teflon®, they will also exhibit the same deposition patterns as field samples since the aerosol chamber is attached to an actual IMPROVE sampler. Although the initial development work has focused on the preparation of Teflon® filter samples, the aerosol generation system should also be applicable to the preparation of samples on quartz and nylon filters.

The new system will also allow the study of interference in the XRF analysis. Sulfur and silicon, for example, lie close to one another in the XRF spectrum, and large amounts of sulfur relative to silicon can cause interferences to the silicon peak. By varying the relative amounts of compounds in the atomized solution, it will be possible to investigate such interferences under controlled conditions. In addition to preparing laboratory filters with the selected elements, it will also be possible to add controlled amounts of elements to field samples to investigate the effects of higher concentrations and related interferences.

System design

The aerosol generation system, housed at Crocker Nuclear Laboratory at UC-Davis, consists of three major parts: 1) an atomizer to create a fine aerosol from a liquid solution, 2) a mixing chamber to provide a uniform airmass from which to sample, and 3) an IMPROVE sampler module (cyclone, filter assembly, and pump) to allow samples to be collected under the same conditions as IMPROVE filter samples. A diagram of the aerosol generation system is shown in Figure 1 and a photograph is shown in Figure 2.

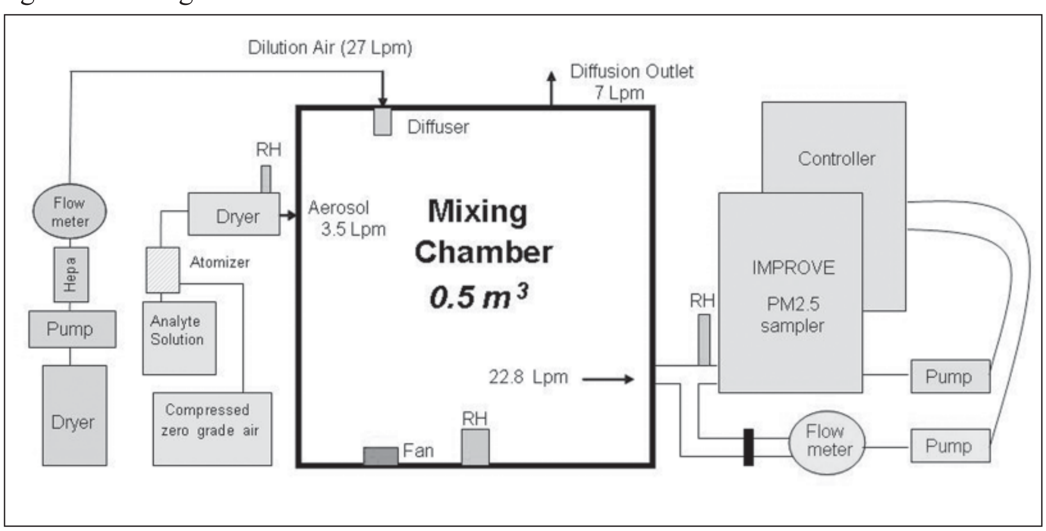


Figure 1. Operational diagram of the aerosol generation system at UC-Davis.

Aerosol deposits are generated from a solution with a constant-output-atomizer using compressed zero-grade air with a flow rate of 3.5 lpm. Aerosols are dried with a diffusion-dryer before entering the 0.5 m^3 dilution chamber. Low relative humidity and particle-free dilution air is introduced into the chamber at a flow rate of 27.0 lpm. The aerosol stream and dilution air are well mixed in the chamber before being pulled through an IMPROVE $PM_{2.5}$ sampler operating with a flow rate of 22.8 lpm, which is the typical flow rate for IMPROVE samplers. Relative humidity in the chamber is measured continuously to ensure it remains below 20%. The IMPROVE $PM_{2.5}$ sampler allows four consecutive samples to be collected with sampling times varying between 10 seconds and 24 hours. The amount of the aerosol deposit is a function of solute, solution concentration, and sampling time.

Results

Most of the development work thus far has focused on generating ammonium sulfate. Ammonium sulfate is one of the major components of most ambient aerosols, and it presents only one element (sulfur) that is detectable by XRF, so it is not subject to cross-element spectral interference. More recently, potassium chloride samples have been prepared. Potassium chloride was chosen because it easily aerosolized and both elements are detected well by the UC-Davis XRF system. Solutions were made with 99.999% pure compounds in HPLC-grade de-ionized water. Solution strengths on the order of 0.0001 to 0.1 M (Molarity) were utilized to generate aerosols. For these concentrations, sampling times were between 30 seconds and 21 minutes. Blank filters were also created using pure HPLC-grade deionized water with sampling times of 25 and 50 minutes.

The mass on each blank and analyte filter was determined by gravimetric mass analysis. The measured mass of ammonium sulfate and potassium chloride was converted to mass of S, K, and Cl assuming that the pure (no water or impurities) compound was collected. After the filters were weighed, they were analyzed by the IMPROVE Cu vacuum XRF system (Cu-XRF). Some of the ammonium sulfate filters have been analyzed by ion chromatography (IC) as a secondary reference for mass. Ultimately, it is hoped that gravimetric mass will provide an accurate value for the mass of material deposited on the filter. IC is a destructive technique (it requires digestion of the filter in solution), so it cannot be performed *a priori* to determine the concentration before XRF analysis. Ongoing testing and development work is focusing on establishing the reliability of gravimetric mass as a quantitative technique for accurately determining the sample mass of the filters produced by the aerosol generating system.

Aerosol generation continued on page 6....

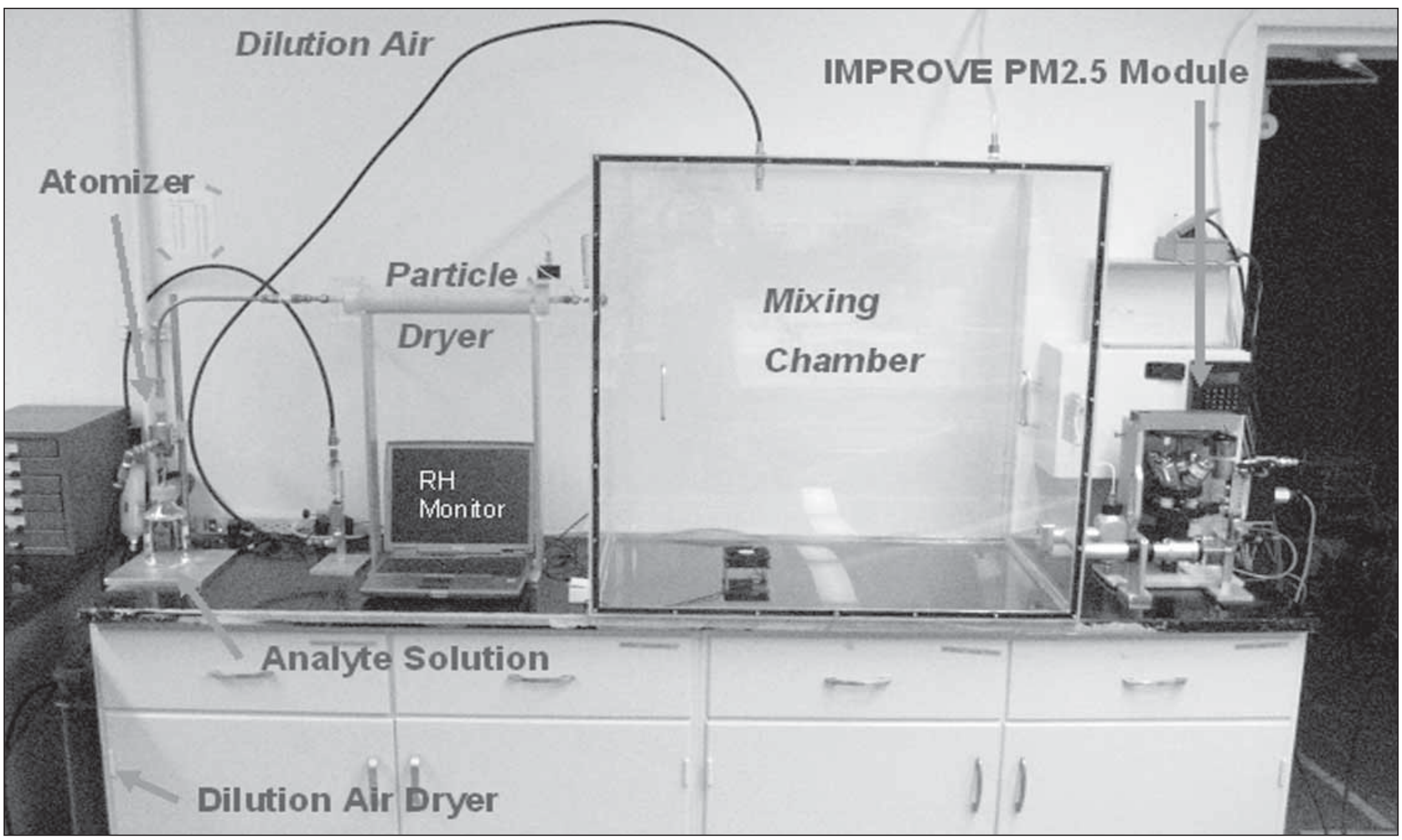


Figure 2. Photograph of the aerosol generation system at UC-Davis.

Aerosol generation *continued from page 5....*

Figure 3 illustrates preliminary results of some of the first system tests, showing a cross-comparison of sulfur mass per filter determined by IC and by gravimetric mass. It is apparent that the IC and gravimetric mass measurements agree well, suggesting that weighing the deposited mass provides a reliable assessment of its elemental concentration. The filter loadings shown here are typical of those observed in the IMPROVE network. An ambient sulfur concentration of 3 µg m^{-3}, for example, equates to about 100 µg/filter.

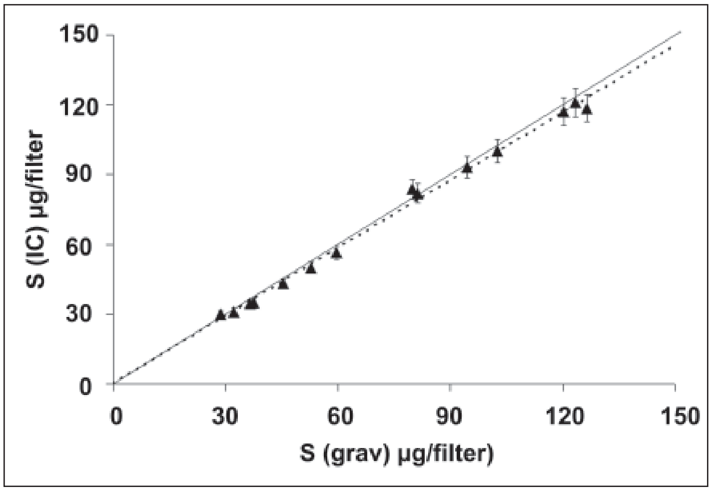


Figure 3. Comparisons of sulfur mass per filter as determined by IC and gravimetric mass analysis on Teflon® filter samples made with pure ammonium sulfate.

To ensure the highest quality data and to make gravimetric measurement of the filters a reliable method for determining the mass of elements of interest, it is important to fully characterize the chamber and filters to ensure that there is no contamination on the filters (no water or other material) and that the compounds in the solution are stoichiometrically transferred to the filter. Filter handling procedures are being carefully developed and tested to ensure that deposit amounts are known with a high degree of precision and accuracy. Humidity control is especially important to ensure that gravimetric determinations accurately reflect elemental concentrations and are not biased by adsorbed water. Relative humidity is measured in real time inside the chamber and is maintained well below the efflorescence point of the analyte during sampling (the point at which the particle is effectively dry).

Additional work to ensure that there is no water on the filters is ongoing. The chamber blanks were analyzed gravimetrically and by Cu-XRF. The average gravimetric mass of twelve blanks was 0 ± 1 µg. All filters were within the balance uncertainty of 2 µg. In addition, no major contaminants were found by Cu-XRF in any of the blanks. Laboratory blanks (not exposed filters) and chamber blanks were equivalent. The molar ratio of potassium and chlorine on each filter should be equal to one if the analyte is being transferred to the filter completely. From the preliminary Cu-XRF data from KCl samples, the average molar ratio is 1.00 with a standard deviation of 0.02, which indicates that the analytes in the prepared solutions are correctly and successfully transferred to our filters from the system.

Future work

To more fully characterize the aerosol in the chamber, a TSI scanning mobility particle sizer (SMPS) has been used to measure the particle size and concentration in the chamber during filter generation. This additional tool is used to estimate the mass on the filter prior to analysis. Multiple analysis by gravimetric and XRF analyses of single samples produced in the chamber is also being considered to provide bases for better determination of analytical uncertainties.

In the future, broader ranges of concentrations of elements will be deposited onto filters to study detection limits and saturation effects. Other multi-species deposits will be created as well, to help understand and evaluate some possible inter-elemental effects that may be contributing to measurement bias. Development and testing of the aerosol generation system will continue throughout the upcoming year. Filters prepared with this system are expected to provide a valuable independent assessment of the accuracy of the IMPROVE elemental concentration data.

For more information contact Chuck McDade at the University of California-Davis. Telephone: 530/752-7119. Fax: 530/752-4107. E-mail: mcdade@crocker.ucdavis.edu.

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

Data advisory released

Data losses during episodes of heavy smoke

- Affects: Module A - Fine mass, elements, f_{abs}
- Period: All

The Teflon® membrane filters used in modules A and D of the IMPROVE sampler can clog and rupture at the high organic carbon (OC) concentrations associated with some regional fire events. Mass, elemental, and light absorption data can thus be under-represented (biased) during episodes of dense smoke. The degree to which bias may affect a particular data analysis can usually be assessed from the ion and carbon data, as the nylon and quartz filters used in modules B and C rarely clog.

A complete discussion of this and all other data advisories can be found on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/Data/QA_QC/Advisory.htm.*

For more information or to submit an advisory, contact Bret Schichtel at CIRA. Telephone: 970/491-8581. Fax: 970/491-8598. E-mail: schichtel@cira.colostate.edu.

Monitoring update *continued from page 3 ....*

Outstanding sites

Data collection begins with those who operate, service, and maintain monitoring instrumentation. IMPROVE managers and contractors thank all site operators for their efforts in caring for IMPROVE and IMPROVE Protocol networks. Sites that achieved 100% data collection for 4th Quarter 2008 are:

Aerosol (Channel A)

Acadia	Great Basin	Proctor Research Ctr
Addison Pinnacle	Great River Bluffs	Puget Sound
Arendtsville	Great Sand Dunes	Quabbin Reservoir
Badlands	Great Smoky Mtns	Quaker City
Bandelier	Haleakala	Queen Valley
Big Bend	Haleakala Crater	Rocky Mountain
Bondville	Hawaii Volcanoes	Salt Creek
Boundary Waters	Ike's Backbone	Sawtooth
Bridgton	James River	Seney
Brigantine	Jarbidge	Sequoia
Bryce Canyon	Kaiser	Shamrock Mines
Caney Creek	Lake Sugema	Shenandoah
Cedar Bluff	Linville Gorge	Shining Rock
Chassahowitzka	Mammoth Cave	Snoqualmie Pass
Cloud Peak	Martha's Vineyard	Starkey
Cohutta	MK Goddard	Tallgrass
Crater Lake	Monture	Theodore Roosevelt
Craters of the Moon	Moosehorn	Three Sisters
Denali	Nebraska	Trapper Creek-Denali
Dolly Sods	New York	UL Bend
Douglas	Northern Cheyenne	Viking Lake
Egbert	Okefenokee	Virgin Islands
El Dorado Springs	Organ Pipe	Weminuche
Ellis	Pasayten	Wheeler Peak
Everglades	Pinnacles	White Mountain
Fresno	Point Reyes	Wind Cave
Frosturg Reservoir	Presque Isle	Yellowstone
Fort Peck		

Nephelometer

Big Bend	Hance	Sierra Ancha
Glacier	Indian Gardens	Tucson Mountain
Greer	Mammoth Cave	Thunder Basin

Transmissometer

-- none --

Photographic

-- none --

Monitoring Site Assistance:
Aerosol sites: contact University of California-Davis
telephone: 530/752-7119 (Pacific time)

Optical/Scene sites: contact Air Resource Specialists, Inc.
telephone: 970/484-7941 (Mountain time)

Sites that achieved at least 95% data collection for 4th Quarter 2008 are:

Aerosol (Channel A)

Bliss	Death Valley	Phoenix
Cabinet Mountains	Guadalupe Mountains	San Rafael
Canyonlands	Indian Gardens	Simeonof
Cape Cod	Isle Royale	Sula
Capitol Reef	Livonia	Trinity
Cherokee	Mohawk Mountain	White Pass
Chiricahua	Mount Baldy	Wichita Mountains
Columbia Gorge East	Penobscot	

Nephelometer

Craycroft	Mount Rainier	Rocky Mountain
Chiricahua	Mount Zirkel	Shenandoah
Children's Park	Organ Pipe	Sycamore Canyon
Estrella	Petrified Forest	Tucson
Great Basin	Phoenix	Vehicle Emissions
Ike's Backbone	Queen Valley	

Transmissometer

Cloud Peak

Photographic

Agua Tibia
Gates of the Mountains

Sites that achieved at least 90% data collection for 4th Quarter 2008 are:

Aerosol (Channel A)

Agua Tibia	Grand Canyon	Olympic
Blue Mounds	Hells Canyon	Petersburg
Bosque del Apache	Hercules-Glades	Sac and Fox
Breton	Hoover	Saguaro
Bridger	Kalmiopsis	San Gorgonio
Cadiz	Lassen Volcanic	San Pedro Parks
Casco Bay	Makah	Sikes
Columbia Gorge West	Medicine Lake	Sipsey
Crescent Lake	Mesa Verde	Tonto
Dome Land	Mingo	Tuxedni
Gates of the Mountains	Mount Hood	Voyageurs
Gila	North Absaroka	Washington DC
Glacier	North Cascades	Zion Canyon

Nephelometer

Cape Romain	Dysart	Great Smoky Mtns.
Cloud Peak		

Transmissometer

Bridger

Photographic

-- none --

IMPROVE

The IMPROVE Newsletter

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525

TO:

First Class Mail

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.

U.S. EPA
Neil Frank
US EPA MD-14
Emissions, Monitoring and Analysis Div.
Research Triangle Park, NC 27711
Telephone: 919/541-5560
Fax: 919/541-3613
E-mail: frank.neil@epa.gov

NPS
William Malm
Colorado State University
CIRA - Foothills Campus
Fort Collins, CO 80523
Telephone: 970/491-8292
Fax: 970/491-8598
E-mail: malm@cira.colostate.edu

USDA-FS
Scott Copeland
USDA-Forest Service
Washakie Ranger Station
333 E. Main Street
Lander, WY 82520
Telephone: 307/332-9737
Fax: 307/332-0264
E-mail: copeland@CIRA.colostate.edu

USFWS
Sandra Silva
US Fish and Wildlife Service
7333 W. Jefferson Avenue
Suite 375
Lakewood, CO 80235
Telephone: 303/914-3801
Fax: 303/969-5444
E-mail: sandra_v_silva@fws.gov

BLM
Scott F. Archer
USDI-Bureau of Land Management
National Science and Technology Center
Denver Federal Center, Building 50
P.O. Box 25047, ST-180
Denver, CO 80225-0047
Telephone: 303/236-6400
Fax: 303/236-3508
E-mail: scott_archer@blm.gov

MARAMA
David Krask
Maryland Dept. of the Environment
MARAMA/Air Quality Planning and Monitoring
1800 Washington Blvd.
Baltimore, MD 21230-1720
Telephone: 410/537-3756
Fax: 410/537-4243
E-mail: dkrask@mde.state.md.us

NESCAUM
Rich Poirot
VT Agency of Natural Resources
103 South Main Street
Building 3 South
Waterbury, VT 05676
Telephone: 802/241-3807
Fax: 802/244-5141
E-mail: rich.poirot@state.vt.us

WESTAR
Robert Lebens
715 SW Morrison
Suite 503
Portland, OR 97205
Telephone: 503/478-4956
Fax: 503/478-4961
E-mail: blebens@westar.org

NACAA
Terry Rowles
MO Dept. of Natural Resources
Air Pollution Control Program
P.O. Box 176
Jefferson City, MO 65102-0176
Telephone: 573/751-4817
E-mail: terry.rowles@dnr.mo.gov

NOAA
Marc Pitchford *
c/o Desert Research Institute
755 E. Flamingo Road
Las Vegas, NV 89119-7363
Telephone: 702/862-5432
Fax: 702/862-5507
E-mail: marc.pitchford@noaa.gov
* Steering Committee chair

ASSOCIATE MEMBERS
Associate Membership in the IMPROVE Steering Committee is designed to foster additional comparable 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:

STATE OF ARIZONA
Steven Peplau
Section Manager - Air Assessment
Arizona Dept. of Environmental Quality
1110 W. Washington Street
Phoenix, AZ 85007
Telephone: 602/771-2274
Fax: 602/771-2366
E-mail: peplau.steven@azdeq.gov