INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

2nd Quarter 2004 | The IMPROVE Newsletter | Volume 13 / Number 2

Feature Article: $PM_{2.5}$ mass measurements by nephelometry, 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 all 156 Class I federally protected areas. Additional instrumentation that operates according to IMPROVE protocol in support of the program includes:

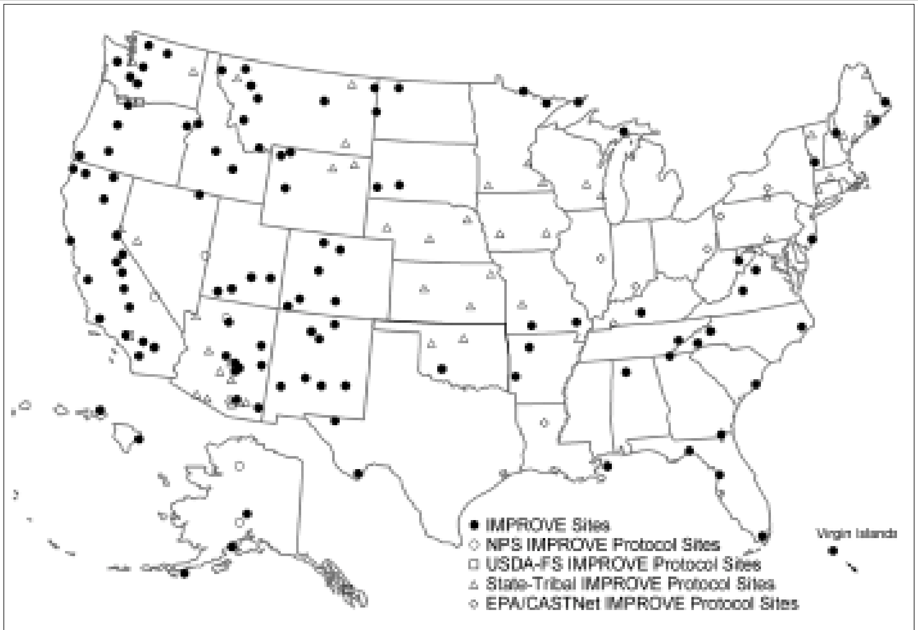
- 55 aerosol samplers
- 19 transmissometers
- 43 nephelometers
- 13 film or digital camera systems
- 43 Web camera systems
- 3 interpretive displays

IMPROVE Program participants are listed on page 8. Federal land managers, states, tribes, and other agencies operate supporting instrumentation at monitoring sites as presented in the map below. Preliminary data collection statistics for the 2nd Quarter 2004 (April, May, and June) are:

- Aerosol (channel A only) 96% collection
- Aerosol (all modules) 95% completeness
- Optical (transmissometer) 96% collection
- Optical (nephelometer) 98% collection
- Scene (photographic) 97% collection

Instrumentation added to the networks this quarter includes aerosol samplers at Frostburg Reservoir, MD (installed April, sponsored by the state of Maryland); Ambler, AK (installed June, sponsored by the National Park Service); and Petersburg, AK (installed June, sponsored by the USDA-Forest Service). A nephelometer was also installed in June at Indian Gardens in Grand Canyon National Park, AZ, (sponsored by the National Park Service and the state of Arizona).

Milwaukee, WI, received both a nephelometer and Web camera system in June, sponsored by the Lake Michigan Air Director's Consortium (LADCO). The images and associated air quality data can be found on the Midwest Hazecam Web site at *http://www.mwhazecam.net.*



IMPROVE and IMPROVE Protocol Sites
2nd Quarter 2004

Data availability status

Data are available on the IMPROVE Web site, at *http://vista.cira.colostate.edu/improve/Data/data.htm*. IMPROVE and other haze related data are also available on the VIEWS Web site, at *http://vista.cira.colostate.edu/views*. Aerosol data are available through October 2003. Transmissometer data are available through December 2002 and nephelometer data are available through March 2004. Photographic slide spectrums are also available on the IMPROVE Web site, under *Data*.

***Monitoring update* continued on page 3....**

Visibility news

IMPROVE steering committee meets at Glacier National Park

Glacier National Park and the National Park Service hosted the annual IMPROVE Steering Committee meeting in June. The two-day meeting began with a welcome from park officials, and ended with a tour of the monitoring sites.

Major topics presented and discussed included:

- The status of network operations
- Investigations and special studies
- Aerosol analytical methods
- Aerosol data interpretation
- Optical instrument testing
- Enhancements to the IMPROVE Web site
- The audit and quality assurance programs

The IMPROVE Program always holds its annual meetings near one or more of the network monitoring sites so that the meeting agenda can include a site visit, where attendees talk with the operators about the program, and view the monitoring shelter, its setting, and the monitoring equipment. This also serves to remind the meeting participants that these areas are the reasons why this program exists, and to allow them to experience the visibility conditions during their visit and scenic value of the region.

Presentations from the meeting can be found on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/Activities/activities.htm.*

Participants of the IMPROVE Steering Committee meeting in Glacier National Park, Montana, discussed current research efforts and the program's direction.

WRAP attribution of haze project

The Western Regional Air Partnership (WRAP) Technical Oversight Committee has formed a workgroup to oversee the 2004 Attribution of Haze (AoH) project. The AoH workgroup has a Web page at *http://www.wrapair.org/forums/aoh/index.html*. This project will result in a policy-relevant report describing the emissions source categories and geographic source regions presently contributing to visibility impairment at each mandatory federal and tribal Class I area in the WRAP region. The AoH workgroup will be integrating EPA technical and policy guidance, analytical results, and data from the following:

- Source apportionment modeling simulations from the WRAP Regional Modeling Center [*http://pah.cert.ucr.edu/aqm/308/*];
- Air mass back trajectory and receptor-oriented analyses of aerosol monitoring data from the WRAP Ambient Monitoring & Reporting Forum's "Causes of Haze" project [*http://coha.dri.edu/index.html*];
- Existing and refined emissions inventories prepared by the various emissions-related WRAP Forums;
- Special-purpose visibility impairment attribution studies such as BRAVO, MOHAVE, etc.;
- EPA technical guidance documents and analyses related to regional haze; and
- Journal publications and workshop/conference reports related to emissions and visibility impairment.

The 2004 AoH project report will be completed in January 2005. This project is the first of several iterative analysis steps for the WRAP, toward the 2007 regional haze plan deadline for all states. The next step will be an analysis project examining what emissions are controllable, and the development of strategies to address those emissions. A subsequent AoH project, to begin in mid-2005, would then analyze additional, more complete data and analytical results, and issue a final report in 2006 for state and tribal regional haze implementation planning purposes. The primary purpose of the 2004 AoH project report is to provide air regulators an initial, detailed assessment of the geographic regions and source categories affecting the Class I areas for which they are responsible.

For more information contact Tom Moore at the Cooperative Institute for Research in the Atmosphere (CIRA). Telephone: 970/491-8837. Fax: 970/491-8598. E-mail: mooret@cira.colostate.edu.

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

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

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 2nd Quarter 2004 are:

Aerosol

Acadia	Dolly Sods	Queen Valley
Addison Pinnacle	Douglas	Rocky Mountain
Ambler	El Dorado Springs	Sac and Fox
Arendtsville	Everglades	Saguaro
Atlanta	Glacier	St. Marks
Badlands	Grand Canyon	Salt Creek
Bandelier	Great Sand Dunes	San Gabriel
Birmingham	Great Smoky Mountains	San Gorgonio
Bliss	Hawaii Volcanoes	Seattle
Blue Mounds	Hells Canyon	Seney
Bondville	Hercules-Glades	Sikes
Brenton	Hillside	Simeonof
Bridger	Hoover	Sipsey
Bridgton	Houston	Snoqualmie Pass
Brigantine	Ike's Backbone	Starkey
Cabinet Mountains	Isle Royale	Swanquarter
Cadiz	James River	Tallgrass
Caney Creek	Jarbidge	Three Sisters
Canyonlands	Joshua Tree	Thunder Basin
Cape Cod	Kalmiopsis	Tonto
Casco Bay	Livonia	Trapper Creek - Denali
Cedar Bluff	Lye Brook	Trinity
Chassahowitzka	Mammoth Cave	Tuxedni
Cherokee	Meadview	UL Bend
Chiricahua	Mesa Verde	Walker River
Cloud Peak	MK Goddard	Weminuche
Cohutta	Moosehorn	White Mountain
Columbia Gorge East	Mount Hood	White Pass
Connecticut Hill	Okefenokee	White River
Death Valley	Petersburg	Wichita Mountains
Denali	Pinnacles	Wind Cave
Detroit	Point Reyes	Yellowstone
	Presque Isle	

Transmissometer

Grand Canyon (In Canyon)	Petrified Forest

Nephelometer

Big Bend	Mammoth Cave	National Capital-Central
	Mount Rainier	

Photographic

Wichita Mountains

Operators of distinction

Phoenix, the nation's 7th most populated city, is home to nearly a dozen air quality sites, and is part of Arizona's comprehensive air quality program. The program requires constant watch, and Terry Taflinger makes certain that 15 monitoring sites are up and running as much as possible. Terry, an air quality instrumentation specialist for the Arizona Department of Environmental Quality (ADEQ), assists site operators in Phoenix and around the state. His assistance and experience in troubleshooting all those systems pays off. With his efforts and those of primary site operator Warren Mason, the Phoenix IMPROVE aerosol site collected 92% of all data from the primary sampler during 2004, and 100% of all data from the collocated sampler.

Terry joined the ADEQ in 1985. "I worked on a little bit of everything back then," said Terry, "gaseous samplers, particulate samplers, and different types of visibility instrumentation. Now I primarily troubleshoot systems, perform instrument calibrations, and install monitoring stations." He installed the newest IMPROVE Protocol aerosol site in Douglas, AZ, in June, which Jose Rodriguez will be the primary operator for. The site includes an IMPROVE aerosol sampler and two R&P 2000 particulate matter samplers on a monitoring support structure.

Terry gained his troubleshooting experience in the US Air Force, where he served as a radar maintenance and electronics technician. After discharge he spent 14 years installing and maintaining cable TV lines. He then got into the air quality field by operating a monitoring site near a copper mine in Arizona for several years. When the mining industry fell economically, Terry moved to Phoenix and joined the ADEQ.

While not too fond of the Phoenix heat, Terry visits his grandchildren as much as he can in the city. He also likes to travel to the mountains, take an ocean vacation, or visit relatives in California and his native Indiana.

Terry Taflinger troubleshoots and installs monitoring sites in Arizona.

Feature article

$PM_{2.5}$ mass measurements by nephelometry in Acadia National Park

(by C. Archuleta, J. Adlhoch, and J. Molenar, Air Resource Specialists, Inc.)

Introduction

The deployment of a $PM_{2.5}$ monitoring network is a critical component in the national implementation of $PM_{2.5}$ mass standards. The Optec NGN-3 size-cut nephelometer was designed to compliment standard filter-based aerosol samplers with continuous $PM_{2.5}$ measurements. These nephelometers are capable of making highly accurate continuous measurements of aerosol scattering, but some uncertainty is introduced when a light scattering measurement is used to determine particle mass. Most of the uncertainty is because the measured aerosol scattering coefficient is not linearly proportional to aerosol mass, but rather it is a complex function including the ambient aerosol size distribution, density, and refractive index.

During 2002 (January 1 through December 31), a $PM_{2.5}$ sampling campaign was run in Acadia National Park, Maine, to test the performance of an Optec NGN-3 nephelometer against a Rupprecht & Patashnick (R&P) Partisol-Plus 2025 $PM_{2.5}$ sequential gravimetric sampler, and an IMPROVE modular aerosol sampler. An Optec NGN-2 ambient nephelometer also operated alongside these instruments. The Optec nephelometers sampled continuously and provided 1-hour averages. The R&P sampler was an EPA federal reference method sampler (hereafter referred to as the FRM sampler) provided 24-hour data. The IMPROVE sampler, where $PM_{2.5}$ is determined gravimetrically from the Module A Teflon filter, also provided 24-hour $PM_{2.5}$ data approximately every third day.

Nephelometer theory

The Optec NGN-3 nephelometer measures dry scattering of fine mass and was designed as a surrogate for $PM_{2.5}$ mass sampling. Both NGN-2 and NGN-3 nephelometers operate by collecting air samples through an optical measuring chamber and illuminating the samples with light over a range of visible wavelengths (0.55μm effective center wavelength). The amount of light scattered (at angles between 5° and 175°) by particles suspended in the sample is measured and used to estimate a particle scattering coefficient. Unlike the ambient NGN-2, the NGN-3 uses a spiral sampler inlet with a 2.5μm size cut and an in-line heater. Conversion of the particle scattering to mass is accomplished with a constant user-defined mass scattering efficiency (α_m):

$$PM_{2.5}\,(\mu g/m^3) = \frac{b_{sp}(Mm^{-1})}{\alpha_m(m^2/g)}$$

In reality, mass scattering efficiency is determined by the aerosol size distribution, density, and refractive index. Based on published studies of the natural variability of these parameters for fine mass, Molenar[1] has generated a frequency distribution of possible α_m with a geometric mean of 2.8 m^2/g and 95% confidence limits of 1.3 to 6.2 m^2/g. For this study, a constant mass scattering efficiency of 3.0 m^2/g was used.

Data results

Data points collected from the NGN-3 nephelometer were compared to the NGN-2, the FRM sampler, and the IMPROVE sampler. Results of each comparison are discussed below.

NGN-3 and NGN-2

Comparisons of hourly averages of b_{sp} from the collocated NGN-3 and NGN-2, for ambient relative humidity (RH) ranging between 15% and 100%, indicated that the NGN-3 read the same as or below the NGN-2 reading. This was expected, as the NGN-3 includes a $PM_{2.5}$ size cut, and an in-line heater which should eliminate the effects of particle growth due to relative humidity. On an hourly basis, correlation between these instruments was reasonably high, with an r^2 of 0.85. As expected, the difference between the measurements increased as RH increased.

NGN-3 and FRM sampler

The NGN-3 was collocated with the FRM sampler operated by the Maine Department of Environmental Protection. The FRM sampler collected 24-hour $PM_{2.5}$ data; 185 data points were available for the comparison, with mass ranging between 1 and 45 $\mu g/m^3$.

Figure 1 shows the comparison between daily averages of the NGN-3 mass ($\alpha = 3\ m^2/g$) and the FRM daily values. The correlation is good, with an r^2 of 0.91. The slope is close to 1, but there is an intercept offset of about -2 $\mu g/m^3$.

Figure 2 shows the distribution of the differences between the NGN-3 $PM_{2.5}$ mass and the FRM mass. The mean difference between the samplers was about -1.95 $\mu g/m^3$ (similar to the offset in Figure 1), with a standard deviation of 2.26 $\mu g/m^3$. Because the NGN-3 is a heated instrument, volatilization of ammonium nitrate and volatile organic compounds is likely a contributing factor for lower NGN-3 measurements.

NGN-3 and IMPROVE module A

The NGN-3 was also collocated with an IMPROVE aerosol sampler, which collected daily averages on a one-in-three day schedule; 77 data points were available for the comparison.

Figure 3 shows the comparison between daily averages of NGN-3 mass (α= 3 m^2/g) and the IMPROVE daily $PM_{2.5}$ values. Again, the correlation is good with an r^2 of 0.92. The slope is close to 1, but an intercept offset of approximately -1.3 $\mu g/m^3$ exists, which is less than that measured against the FRM sampler (-1.99).

Figure 4 shows the distribution between the NGN-3 $PM_{2.5}$ mass and the IMPROVE mass. The mean difference between the NGN-3 $PM_{2.5}$ mass and the IMPROVE mass was about -1.35 $\mu g/m^3$, with a standard deviation of 1.70 $\mu g/m^3$. The data do not quite fit a normal distribution because the distribution is biased towards the low end. Again, volatilization of ammonium nitrate and volatile organic compounds was likely influenced by the lower NGN-3 measurements.

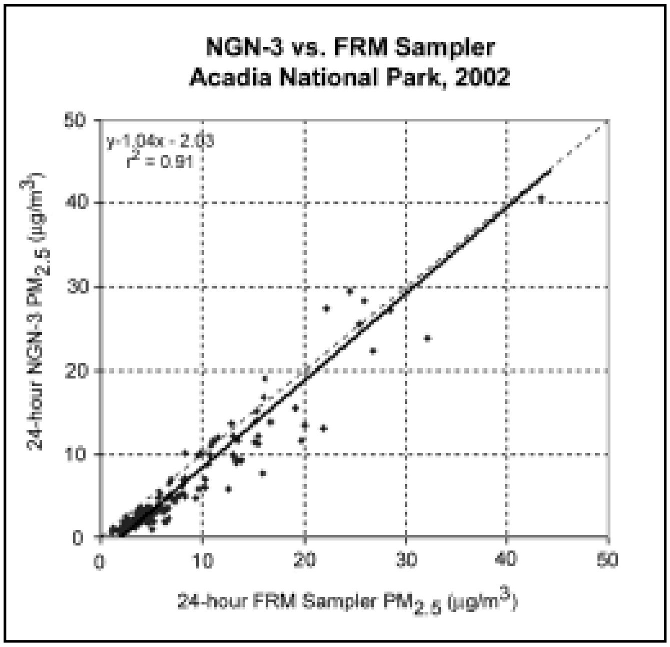


Figure 1. Comparison of 24-hour averages of $PM_{2.5}$ for collocated NGN-3 and FRM sampler.

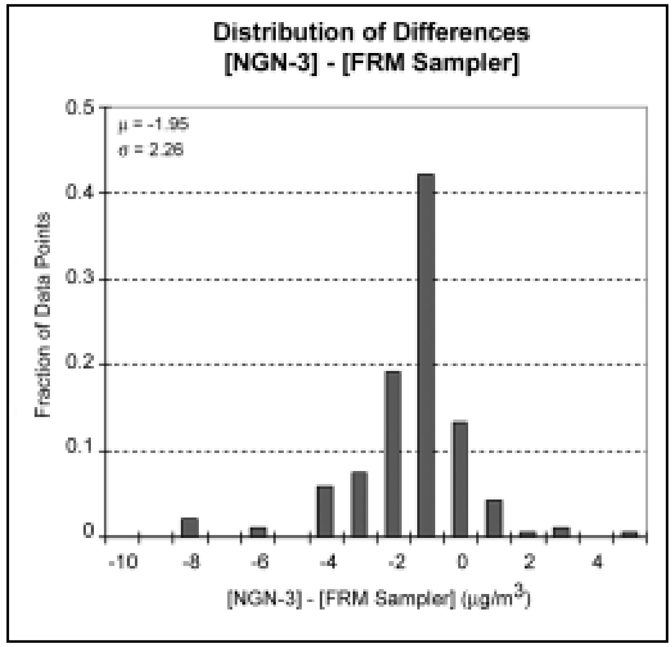


Figure 2. Distribution of the differences between NGN-3 $PM_{2.5}$ mass and FRM mass.

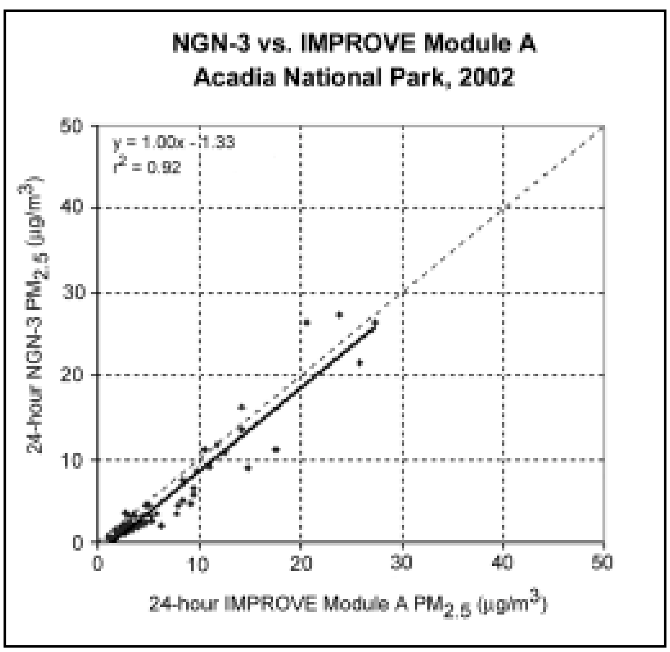


Figure 3. Comparison of 24-hour averages of $PM_{2.5}$ for collocated NGN-3 and the IMPROVE modular aerosol sampler.

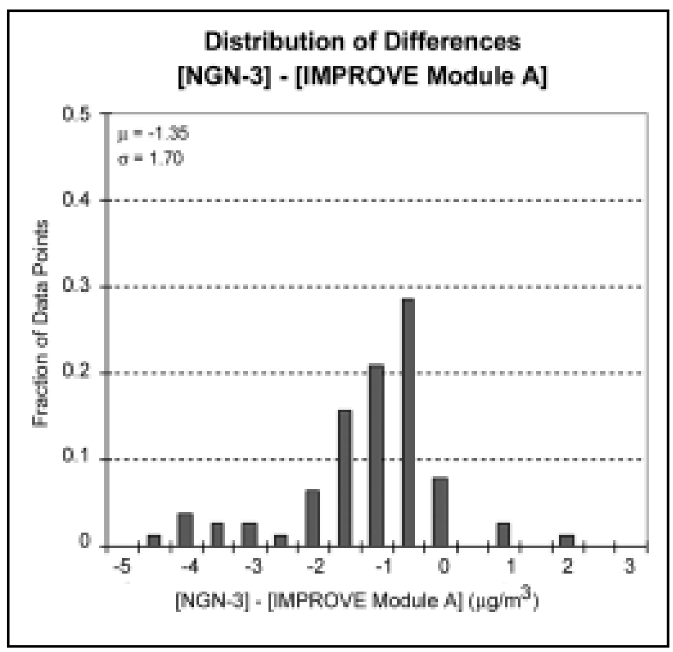


Figure 4. Distribution of the differences between NGN-3 $PM_{2.5}$ mass and IMPROVE mass.

***$PM_{2.5}$ mass measurements** continued on page 6....*

***$PM_{2.5}$ mass measurements** continued from page 5....*

Conclusions

The NGN-3 was designed to continuously monitor $PM_{2.5}$ mass based on calculations using the measured dry particle scattering. Comparisons between collocated NGN-2 and NGN-3 data at Acadia National Park indicate that NGN-3 b_{sp} was almost always at or below NGN-2 b_{sp}, and the differences increased dramatically at higher RH values. This comparison allows some degree of confidence that the NGN-3 eliminated particle growth due to atmospheric moisture.

Results from the $PM_{2.5}$ instruments indicate that the dry particle scattering coefficient of the NGN-3, coupled with a mass scattering efficiency of 3 m^2/g, provides a reasonable estimate of $PM_{2.5}$ mass when compared to both an FRM and the IMPROVE Module A filter-based samplers. Comparison of 24-hour averages yielded r^2 values of 0.91 and 0.92, respectively. There was a tendency for the calculated mass from the NGN-3 to be slightly lower than the filter-based measurements, averaging -1.95 $\mu g/m^3$ lower than the FRM sampler, and -1.35$\mu g/m^3$ lower than the IMPROVE sampler. The NGN-3 was heated to remove liquid water, which likely contributed negative volatilization biases. Higher temperatures resulted in higher volatilization of ammonium nitrate and volatile organic compounds. For this year-long study, chamber temperatures for the nephelometer ranged between 24.8°C and 44.9°C and averaged about 36.7°C.

Results from this field study indicate that the NGN-3 was capable of providing a reasonable estimate of $PM_{2.5}$ mass for the conditions that existed in Acadia National Park in 2002, with daily FRM mass averages between 1 and 45 $\mu g/m^3$, hourly temperatures between -20°C and 35°C, and hourly RH conditions that ranged between 15% and 100%. Because the daily averages of NGN-3 mass compared well with daily filter samples, it is reasonable to assume that, under similar conditions, the NGN-3 is capable of making continuous $PM_{2.5}$ measurements on a time scale shorter than 24 hours.

References

[1] Molenar, J.V., 2000, Theoretical Analysis of $PM_{2.5}$ Mass Measurements by Nephelometry, *Air & Waste Management Association Specialty Conference*, PM2000: Particulate Matter and Health, January 24-28, 2000, Charleston, SC.

For more information contact Cassie Archuleta at Air Resource Specialists, Inc. Telephone: 970/484-7941. Fax: 970/484-3423. E-mail: Carchuleta@air-resource.com.

Visibility news

continued from page 2 ....

Spatial representativness of IMPROVE sites

Three IMPROVE aerosol network monitoring sites are the center of an analysis study, to determine if the program's objectives are being met. These objectives are to establish current visibility and aerosol conditions and provide regional haze monitoring in Class I areas. The network is designed to minimize the number of monitoring sites needed to meet these objectives.

For several months in 2003, paired IMPROVE samplers operated in three Class I areas: San Gorgonio Wilderness, CA (SAGO); Zion National Park, UT (ZION); and Badlands National Park, SD (BADL). UC-Davis scientists are using data from these paired sites to evaluate the spatial representativeness of each site.

The paired samplers operated at SAGO and ZION to determine if new site locations were comparable to old site locations within the same area. The samplers were located approximately 250 m apart and 30 km apart, at SAGO and ZION, respectively. The new ZION site, renamed Zion Canyon (ZICA), is also located in a canyon, approximately 300 m below the old site. The paired samplers operated at BADL to determine if emissions from a nearby road and park facilities impact the existing sampler. These samplers were located approximately 23 km apart.

Preliminary analysis shows that the paired samplers at all three locations compared well; the average difference between reconstructed haze indices was 0.66 dv at SAGO, 1.1 dv at ZION, and 0.67 dv at BADL (1 deciview (dv) difference is equivalent to a 10% difference in visibility). Concentrations of major species, including sulfate, nitrate, organic carbon, and elemental carbon, tracked well at the sites. Sulfate concentrations measured at the SAGO and BADL sites were similar, indicating that the same regional air parcel impacted the paired samplers, but at times, sulfate concentrations measured at the ZION sites were significantly different indicating that different air parcels may have impacted the two sites on certain days.

Significant differences in some species measured at the sites could often be attributed to known local sources. For example, elemental carbon concentrations were consistently higher at the old ZION site (located closer to an interstate highway), and soil composite concentrations were usually higher at the BADL test site (located closer to a dirt road). These examples illustrate that although local sources can impact an individual sampler, the regional air mass usually dominates the measured $PM_{2.5}$ and PM_{10} concentrations, and thus determines the visibility.

***Site comparisons** continued on page 7....*

***Site comparisons** continued from page 6....*

Concentration differences at the paired sites can exist for a variety of reasons: flow measurement accuracy, differences in cyclone cutpoint resulting from differences in flow rate, differences in sampler arrangement (e.g., sun and wind exposure), analytical accuracy, differences in proximity to local sources, differences in the vegetation immediately surrounding the site, and atmospheric variability.

Collocated measurements (within a few meters of one another) are useful for allocating the differences in the paired site data to either measurement precision or true variations in the aerosol conditions at the paired sites. Several IMPROVE collocated sites were established in 2003 to evaluate the current uncertainty estimates and determine the precision of the measurements. Once sufficient collocated data become available, concentration differences at the paired sites will be compared to differences observed in the collocated measurements, to separate the influences of measurement precision from those of paired site differences.

For more information contact Nicole Hyslop at UC-Davis. Telephone: 530/754-8979. Fax: 530/752-4107. E-mail: hyslop@crocker.ucdavis.edu.

IMPROVE and VIEWS Web site developments

The IMPROVE (*http://vista.cira.colostate.edu/improve/*) and VIEWS (*http://vista.cira.colostate.edu/views/*) Web sites are the official points for disseminating IMPROVE data, metadata, data analyses results, and scientific and education information on the IMPROVE Program, monitoring networks, and regional haze. The IMPROVE Web site focuses on disseminating information generated by the IMPROVE Program and educational material on visibility and haze. The VIEWS Web site is designed around an integrated air quality database incorporating data from multiple monitoring networks such as IMPROVE and CASTNet. A unique feature of the VIEWS Web site is the extensive set of data aggregation and visualization tools designed to generate data analysis results relevant to the regional planning organizations (RPOs) to aid them in implementing the Regional Haze Rule. The VIEWS project has been primarily funded by the RPOs.

Over the past year these two Web sites have gone through extensive modifications adding to their content and updating and improving the tools and their performance.

Aerosol and optical data

The IMPROVE aerosol dataset is updated approximately every month and the nephelometer scattering data are updated every quarter. The online database now allows a single query to the system to produce both scattering and aerosol data in different user selected formats.

VIEWS includes all IMPROVE data and aerosol data from EPA's national Speciated Trends Network (STN); EPA's hourly and daily FRM $PM_{2.5}$ mass; CASTNet; SEARCH (an intensive monitoring network in the rural southeast); and wet deposition data from the AIRMoN network, as well as data from other networks. All datasets are updated every three months or sooner.

The ASCII datasets containing the Regional Haze Rule metrics calculated for tracking trends using the final version of the EPA guidance are now available from both Web sites.

Metadata browsing tool

The metadata browsing tool now incorporates a geographic information system allowing users to navigate through a map by zooming and panning and selecting multiple sites for further inquiry. Additional spatial layers, such as national park boundaries, roads, urban areas, and counties can be overlaid on the monitoring sites, providing additional spatial contexts for each monitoring site. The detailed monitoring description page has also been updated and now includes photographs of all IMPROVE monitors and their surroundings.

Online data query wizard

The data query wizard tool, which allows a user to construct queries against the database to return subsets of the data, has received extensive modifications including additional selection features, output formats, and increased retrieval speed.

Documents

More information is available on the IMPROVE publication and activities pages including all annual reports by the Air Quality Group at University of California - Davis, and presentations from the 2004 IMPROVE steering committee and all subsequent meetings.

Next year a multi-media visibility and air quality educational section will be implemented, that will introduce a visitor to issues and science of regional haze in a fun, interactive tool.

To date, the IMPROVE and VIEWS Web sites average about 1,000 unique visitors monthly, from more than 80 different countries. In addition, over 50 other Web sites have links directing their visitors to the IMPROVE and VIEWS Web sites.

For more information contact Bret Schichtel at the Cooperative Institute for Research in the Atmosphere (CIRA). Telephone: 970/491-8581. Fax: 970/491-8598. E-mail: schichtel@cira.colostate.edu.

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. Steering Committee representatives are:

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@epamail.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

BLM
Scott Archer
Sciences Center (RS-140)
P.O. Box 25047
Denver, CO 80225-0047
Telephone: 303/236-6400
Fax: 303/236-3508
E-mail: sarcher@blm.gov

USDA-FS
Rich Fisher
Air Program Technical Manager
USDA-Forest Service Air Program
2150A Centre Avenue
Fort Collins, CO 80526
Telephone: 970/295-5981
Fax: 970/295-5988
E-mail: rwfisher@fs.fed.us

FWS
Sandra Silva
Fish and Wildlife Service
P.O. Box 25287
12795 W. Alameda
Denver, CO 80225
Telephone: 303/969-2814
Fax: 303/969-2822
E-mail: sandra_v_silva@fws.gov

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: richpo@dec.anr.state.vt.us

STAPPA
Ray Bishop
Dept. of Environmental Quality
Air Quality Division
707 North Robinson
PO Box 1677
Oklahoma City, OK 73101-1677
Telephone: 405/702-4218
Fax: 405/702-4101
E-mail: ray.bishop@deq.state.ok.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

MARAMA
David Krask
Maryland Dept. of the Environment
ARMA/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

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: marcp@snsc.dri.edu
* Steering Committee chair

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:

STATE OF ARIZONA
Darcy Anderson
Arizona Dept. of Environmental Quality
Air Quality Division
1110 W. Washington Street L120A
Phoenix, AZ 85007
Telephone: 602/771-7665
Fax: 602/771-4444
E-mail: anderson.darcy@ev.state.az.us

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

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, & November) under National Park Service Contract C2350010850.

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:

Air Resource Specialists, Inc.
Gloria S. Mercer, Editor
Telephone: 970/484-7941 ext.221
Fax: 970/484-3423
E-mail: info@air-resource.com

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

printed on recycled paper