INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

3rd Quarter 2012 | The IMPROVE Newsletter | Volume 21 / Number 3

Feature Article: Aerosol optical trends at long-term monitoring stations, Page 4

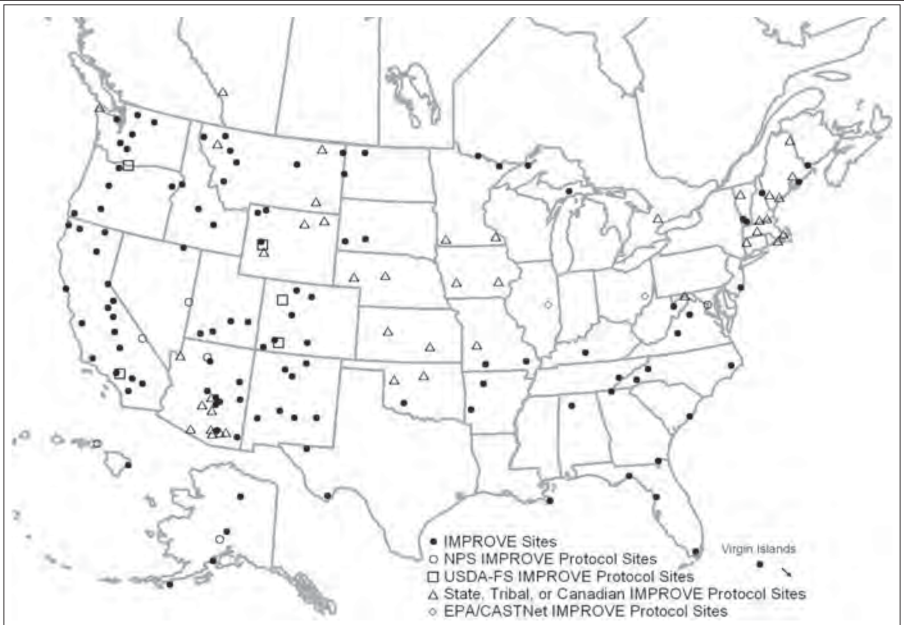
Monitoring update

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. Instrumentation that operates according to IMPROVE protocols in support of the program includes 52 additional aerosol samplers, and optical instrumentation (nephelometers and transmissometers), scene instrumentation (Webcamera systems), and interpretive displays. The Haleakala, HI aerosol site (HALE1) was decommissioned during the quarter.

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 3rd Quarter 2012 (July, August, and September) are:

- Aerosol (channel A only) 94% collection
- Aerosol (all modules) 93% completeness
- Optical (nephelometer) 99% collection



IMPROVE and IMPROVE Protocol Sites
3rd Quarter 2012

Data availability status

Aerosol data are available through December 2011. Nephelometer and transmissometer data are available through May 2012 and December 2011, respectively.

Data and photographic spectrums are available on the:

- IMPROVE Web site
  http://vista.cira.colostate.edu/improve/Data/data.htm
- VIEWS Web site
  http://vista.cira.colostate.edu/views
- Federal Environmental Database (FED)
  http://views.cira.colostate.edu/fed/Default.aspx

Webcamera real-time images and associated air quality data are available on agency-supported Web sites:

- National Park Service
  http://www.nature.nps.gov/air/WebCams/index.htm
- U.S. 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 Visibility Network
  http://www.phoenixvis.net

The U.S. Environmental Protection Agency AIRNow Web site *http://airnow.gov* includes many of these same images, as well as additional visibility-related Webcameras from 33 states and the District of Columbia. Click on “Visibility Cameras” at the AIRNow home page.

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

Visibility news

IMPROVE contributes optical data to World Meteorological Organization atmospheric program for global use

The World Meteorological Organization (WMO) Global Atmosphere Watch Programme (GAW) is a unique, long-term international framework that provides the technical basis for integrated observations, analysis, and assessment of atmospheric chemical composition. The GAW consists of contributing data networks that collect long-term observations of the chemical composition and selected physical characteristics of the atmosphere, to provide products and services to its users. All contributing data are collected according to WMO/GAW quality assurance and quality control standards.

The WMO/GAW currently coordinates integrated global observations of greenhouse gases, ozone, reactive atmospheric gases, aerosols, chemical composition of precipitation, and ultraviolet radiation. Representatives from both the WMO/GAW and IMPROVE organizations entered into an agreement in July 2012, to recognize the IMPROVE-Optical Network as having high precision and accuracy data for light scattering, temperature, and relative humidity data. IMPROVE joins other, contributing networks in the programme with similar data characteristics.

According to the agreement, IMPROVE agrees to adhere to the high quality standards the WMO demands of its contributors, and will submit optical data that are intended for use in GMO/GAW products and services, such as assessments and bulletins.

The IMPROVE optical network currently consists of nephelometer monitoring stations operating in: Acadia, Big Bend, Glacier, Great Basin, Grand Canyon, Great Smoky Mountains, Mammoth Cave, Mount Rainier, National Capitol, Rocky Mountain, and Shenandoah National Parks.

For more information contact Bret Schichtel, National Park Service Air Resources Division, Cooperative Institute for Research in the Atmosphere. Telephone: 970/491-8581. Fax: 970/491-8598. E-mail: Schichtel@cira.colostate.edu.

Phoenix air quality improving, but affected by short-term natural events

The Arizona Department of Environmental Quality (ADEQ), in cooperation with the Maricopa County Air Quality Department and the Pinal County Air Quality Control District, monitors air quality in the greater Phoenix metropolitan area, which is the sixth largest populated city in the U.S. These agencies are responsible for controlling particulate matter <10µm (PM_{10}) emissions from agricultural, fugitive dust, stationary, and open burning sources.

PM_{10} is monitored in the Phoenix area with a variety of monitors. The city's air quality has improved over the past 20 years, and a large portion of this improvement has occurred in the last 5 years. The average and minimum PM_{10} values have decreased approximately 7 µg/m^3 (15%-20% decrease), while the maximum value has decreased 1.5 µg/m^3 (3% decrease) over the 20-year period ending in 2009. The trend continues through 2010, with a small increase in 2011.

The improving air quality, however, is interrupted regularly by natural dust events that originate outside of the metropolitan area. Southern Arizona continued to experience severe to extreme drought conditions into 2011, making soil conditions conducive to windblown transport. Monsoonal thunderstorms often include strong winds with downdrafts that can produce significant dust carrying outflow winds. These dust events, known as haboobs, are often large and dramatic. Hourly PM_{10} concentrations during these events may exceed 5,000 µg/m^3, with 24-hour averages exceeding 300 µg/m^3.

The events of July 2-8, 2011, were particularly noteworthy and are described in detail in ADEQ documentation[1]. The July 5th event is considered historic in nature due to the spatial extent for which elevated PM_{10} concentrations were recorded and its visual impact.

[1] State of Arizona Exceptional Event Documentation for the Events of July 2nd through July 8th 2011 (Draft), Arizona Department of Environmental Quality, Maricopa County Air Quality Department, Maricopa County Association of Governments, 2011.

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

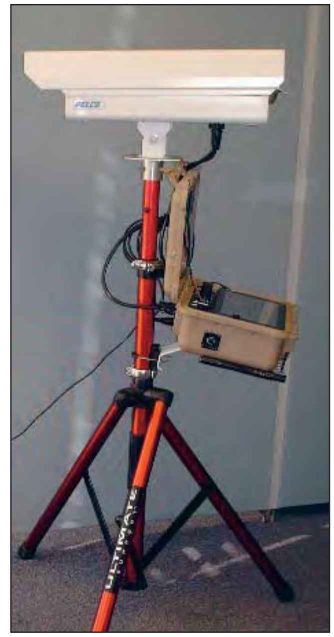
Night camera system to monitor visual intrusion of emissions into park skies

A new type of camera system is being developed to monitor visual conditions in night sky images, which may prove to be another useful monitoring tool for visibility researchers.

On October 10, 2011, the state of Utah, Department of Natural Resources, Division of Oil, Gas and Mining, approved a preliminary permit for the Coal Hollow Mine, the state's first surface strip coal mine. The mine, 3 miles south of Alton and 10 miles south of Bryce Canyon National Park, is expected to produce 2 million tons of coal per year for 3 years.

Several community environmental groups, including the Utah Chapter of the Sierra Club and National Parks Conservation Association, have filed a petition to stop the proposed mine. The petition includes concerns of air and water quality, as well as Bryce Canyon National Park's renowned clear night sky conditions.

The National Park Service (NPS) is working with Air Resource Specialists, Inc. (ARS) to begin photographic monitoring of night sky conditions in Bryce Canyon National Park prior to and during mine construction and operation. ARS has developed a digital single lens reflex (DSLR) camera system based on the systems currently operating in the NPS Webcamera network.



ARS' new DSLR camera system for remote, nighttime monitoring includes a low power operating system, an Android tablet for control, and a very wide angle camera lens.

Night sky camera continued on page 8....

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

Operators of distinction

Stay long enough in an area and you'll see changes. IMPROVE site operator Ted Porwoll can attest to this, as in his 16 years with the Bridger-Teton National Forest Pinedale Ranger District, air quality concerns have taken on new interest with scientists.

Ted, an Air Quality Technician with the U.S. Forest Service, is responsible for the operation of several air and water quality monitoring sites. He services the Bridger (BRID1) and Boulder Lakes (BOLA1) IMPROVE stations, as well as a transmissometer, Webcamera, two National Atmospheric Deposition Program (NADP) monitoring stations, and a Clean Air Status and Trends Network (CASTNet) monitoring station. He also collects rain and snow samples for long-term lake monitoring and long-term bulk precipitation monitoring on the district. These sites are located in the Bridger Wilderness. Each visit requires Ted and his help to snowmobile 10 to 25 miles and then ski another 15 miles to access the sites. In the summer they require a 15-mile hike in and out of the mountains. "In the beginning, precipitation sampling was initiated to check for acid precipitation," said Ted. "Sampling, however, has shown that nitrogen deposition is the real concern." Because of his efforts, Ted has only missed one IMPROVE sample this year, and that was due to a power outage at the site. "It's a half-mile hike to Bridger and about a 20-mile, roundtrip to Boulder Lakes," said Ted. In the winter, which is about half the year in this part of Wyoming, Ted puts 125 miles on the pick-up truck and about 30 miles on the snowmobile every Tuesday while servicing his monitoring sites.

Shortly after earning an Associate of Science degree in Parks and Recreation Management in Minnesota, Ted became a seasonal employee on the Shoshone National Forest in Wyoming, mostly in Wilderness and Trails Management. After a short stint in Ketchikan, AK, Ted accepted a permanent job as Wilderness Manager in the Mount Zirkel Wilderness, CO, where he assisted with special air quality studies and the operation of two NADP and one IMPROVE site near Buffalo Pass. It was this foot in the door to the air quality field that gave him the experience and knowledge to transfer to the full-time air quality technician position on the Bridger-Teton National Forest.

The Upper Green River Valley area, near the Bridger-Teton, has seen wintertime ozone become a central issue in recent years. The Upper Green has become the first ozone non-attainment area in Wyoming, which is remarkable given its rural nature and the fact that wintertime ozone production at these levels hadn't been observed anywhere else before 2003. "Oil and gas development has increased dramatically here. Some fields are now only 8 km from the Class I Bridger Wilderness Area, and two coal-fired power plants are upwind," said Ted, who has also operated an ambient air quality monitoring station for the Wyoming Department of Environmental Quality and served as the field technician for several special studies in the area.

Ted enjoys spending time with his two children — Miles, age 7 and Robin, age 4. He also loves baseball, skiing, and fishing, and readily admits, "I probably do too much fishing."

Monitoring update continued on page 7....

Feature article

Aerosol optical trends measured at long-term GAW and IMPROVE stations

(by M. Collaud Coen, E. Andrews, A. Asmi, U. Baltensperger, N. Bukowiecki, D. Day, M. Fiebig, A.M. Fjaeraa, H. Flentje,A. Hyvärinen, A. Jefferson, S.G. Jennings, G. Kouvarakis, H. Lihavainen, C. Lund Myhre, W.C. Malm, N. Mihapopoulos, J. V. Molenar, C.O'Dowd, J.A. Ogren, B.A. Schichtel, P. Sheridan, A. Virkkula, E. Weingartner, R. Weller, and P. Laj)

Introduction

Over the past few decades, the number of optical monitoring sites has increased globally, generally due to scientific interest and development of more stringent air quality regulations. Few long-term trends in aerosol optical analyses, however, have been studied globally. In study results since 2000, global researchers typically found statistically significant aerosol optical trends that are attributable to both specific changes in local aerosol sources and to continental or global scale regional differences.

Long-term trends analyses are difficult due to the lack of available data over one or more decades. Monitoring networks must have reliable instruments, stations that are appropriately located for area representativeness, and of course, a long-term, quality data record using the same measurement methods. Because of these factors, monitoring locations are rarely seen to have more than a 20-year data record, and hence, there are few publications that address long-term studies of these aerosol optical properties.

This article is a summary of a recent analysis, where in-situ aerosol optical property trends over several decades was performed using World Meteorological Organization/ Global Atmospheric Watch (WMO/GAW) guidelines, and quality controlled data and information provided by the IMPROVE optical network; the National Oceanic and Atmospheric Administration (NOAA)-affiliated monitoring network; the European Monitoring and Evaluation Programme (EMEP); and the EUSAAR/ Aerosols, Clouds, and Trace gases Research InfraStructure (ACTRIS). Researchers hoped to determine if:

- Trends in aerosol optical properties could be detected.
- Trends differ depending on the length of data series.
- Regional and seasonal similarities or differences could be observed in the trends.
- Observed optical property trends compare with trends in other aerosol properties (as reported in other studies).

Optical databases

The analyses used aerosol optical data from 24 monitoring locations globally, as shown in Figure 1. All stations maintained a long-term data record, were remotely located, and were believed to be representative of a large-scale area of continental, mountain, desert, marine, Arctic, and Antarctic environments. Most (17) sites were located in North America, with 5 in Europe and 2 in the Southern Hemisphere.

Data included hourly averaged, validated, light scattering and light absorption measurements taken from the GAW aerosol programme and IMPROVE optical network. Data were measured and recorded on integrating nephelometers (light scattering) and by particle soot absorption photometers and aethalometers (light absorption). Because relative humidity plays a role in the hygroscopicity of particles, and most of the GAW sites operate in conditions <50%

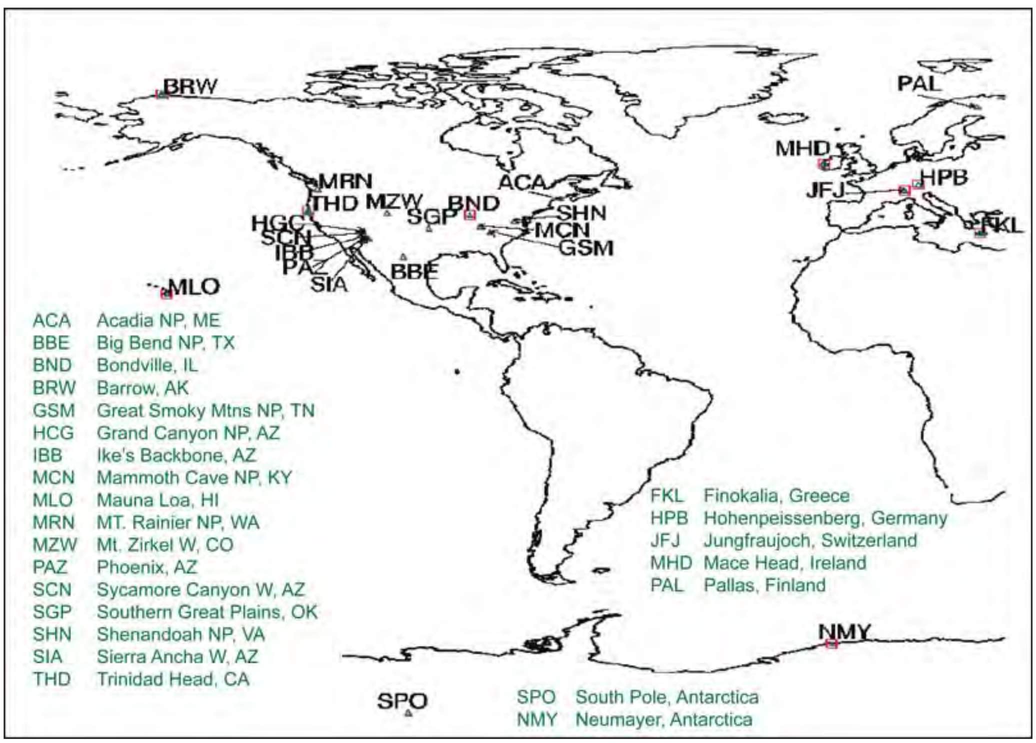


Figure 1. Map of sites; blue triangles indicate sites with scattering data used in this study, red squares indicate sites with absorption data used in this study.

relative humidity, only datasets where relative humidity <50% were used for these scattering analyses. It should be noted that instruments to measure absorption have changed significantly in recent years, leading to a non-homogeneity factor of some datasets. Other non-homogeneous factors included instrument relocations, changes to nearby pollution sources, and changes to data processing methods.

Data analyses

Because the data were not normally distributed, two non-parametric tests were chosen to analyze for trends: 1) the seasonal Mann-Kendall (MK) test associated with the Sen's slope, and 2) a Generalized Least Squares test with either autoregressive or block bootstrap confidence intervals (GLS/ARB). The least-mean square (LMS) fit was also applied to the datasets.

Seasonal Mann-Kendall test

This test is a particular Kendall's tau application which takes into account seasonal effects. To test for a trend (either upward or downward), a two-tailed test at the 95% level of significance was applied to daily median data values. If a linear trend existed, the true slope was estimated using the Sen's slope method. Sen's estimator of the slope is the median of individual slopes of all data pairs; the Sen's slopes were calculated using the median of 24 or 48 hour average data values.

Generalized Least Squares test

The GLS method was used to evaluate the trends identified with the MK test. It is based on ordinary least squares fitting, but includes autocorrelation of the covariance matrix. Combined with an autogregressive bootstrap (ARB) algorithm, it can be used to evaluate differences in GLS trends due to noise terms. Resulting values were used to get the 5th to 95th percentile confidence intervals of the GLS trends.

Least-Mean Squares fit

The standard LMS calculation was used on monthly datasets to obtain trends. Real trends were indicated at the 95% confidence level.

Results

Trends were identified for a 10-year dataset (2001-2010) and for a 15-year dataset (1996-2010). Scattering trends for long-term monitoring sites included 24 datasets from sites in Europe, North America, and Antarctica. The majority of these datasets were IMPROVE nephelometer sites, which were inceptionalized in the 1990s and had good quality data with few breaks in the data record. Detailed scattering results using MK and GLS/ARB analyses methods are presented in Figures 2 and 3. Findings are:

- Trends are generally negative in the U.S., with decreasing trends measured at all sites east of the Rocky Mountains and for the two stations in the Northwest. No consistent trend appears for the five Arizona sites.
- Few trends were observed for the five European sites, which are geographically different ranging from mountaintop to coastal regions.
- A seasonal trend was found for several eastern and western U.S. sites. No significant seasonal trends appear in the European or the polar sites.

Absorption trends were also identified using nine datasets from European, North American, and Antarctic sites. Findings are:

- Absorption trends were available at fewer sites than scattering trends (3 vs. 17), but the trends are similar.

In-situ measurements continued on page 6....

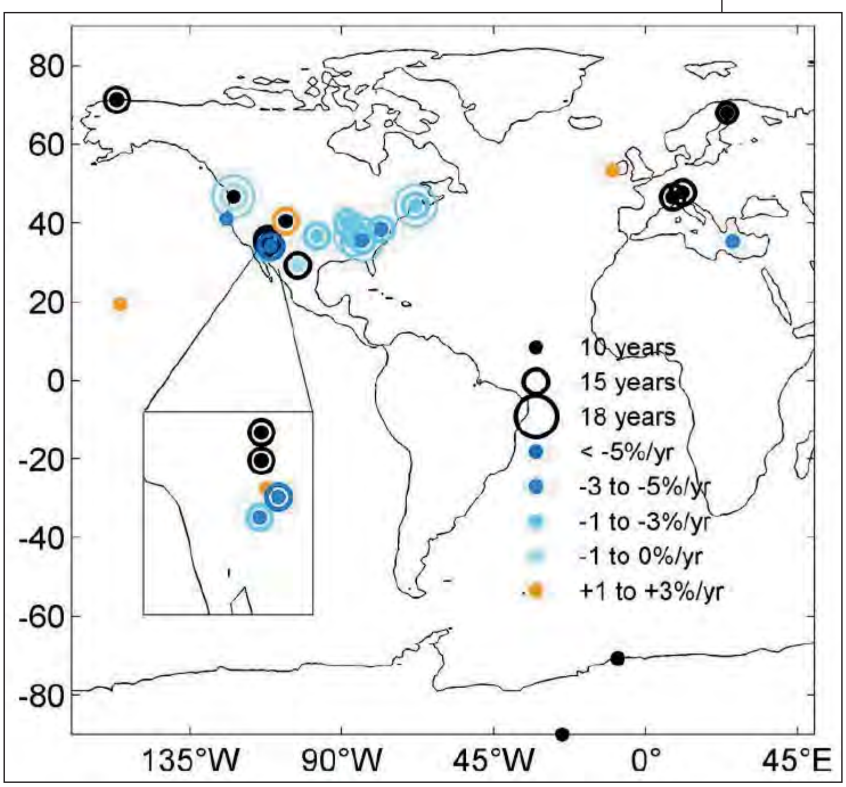


Figure 2. MK trends results for the scattering coefficient. Black symbols correspond to stations with no significant trends. Blue and orange symbols correspond to statistically significant negative and positive trends, respectively, the magnitude of the trends (slope) being given by the colors as stipulated in the legend. The sizes of the circles are proportional to the length of the data sets; the trend for the whole period as well as the 10-year (dots) and if possible 15-year trends were calculated. The largest circles denote therefore the trend of the longest analyzed period.

In-situ measurements continued from page 5....

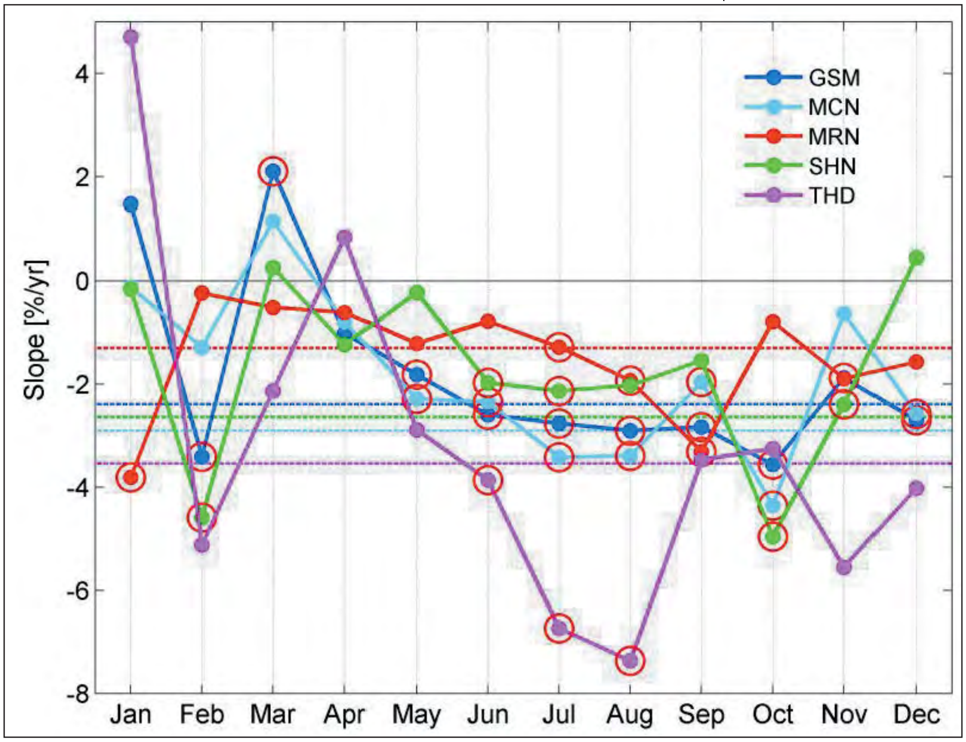


Figure 3. Seasonal Mann-Kendall trend analysis (red circles correspond to 90% confidence levels) associated with Sen's slopes (colored dots) for the scattering coefficients of eastern and northwestern stations. The dotted lines correspond to the annual trend.

- Absorption trends in Europe were derived from four datasets. No trends were apparent for two of the high altitude sites and the marine station for the last 10 years.
- One of the three high altitude sites in Europe showed a positive trend.
- Both polar sites show negative trends, although no trends were observed in these stations' scattering data.
- One polar site showed seasonal trends, with winter absorption decreasing and summer absorption remaining stable. One California site showed the same seasonal trends in scattering and absorption, but no other site showed seasonal trends for absorption.

Conclusion

The scattering and absorption trends observed in this analysis were generally consistent with other researchers' findings — that decreases in particulate matter and sulfur dioxide emissions have resulted from air quality regulations and improving industrial processes. The decreasing trends are also consistent with aerosol chemistry trends from urban observations in the U.S. and in Europe. These decreasing trends were not nearly as apparent in Europe, although considerable reductions in pollutant emissions have occurred over the past 30 years. The lack of trends may be because emission reductions occurred earlier in Europe than in the U.S. and the trend periods analyzed did not go far enough back to capture reductions. Additionally, the lack of monitoring sites covering the continent may be a factor. Polar sites trends do not appear to be influenced by changes in anthropogenic pollution.

Analyses results show that aerosol optical values have significantly changed at many sites over the last 10 to 15 years. Several sites in the U.S. showed increasing scattering and/or absorption trends. Many, but not all, high altitude, desert locations exhibited increasing trends. For example, the Mauna Loa, HI, site is most likely exhibiting increased trends due to long-range Asian transport . Analysis for the Mt. Zirkel, CO, and Ike's Backbone, AZ, show increasing trends that are contradicted by other measurements made at these locations. The datasets at these sites will require further study. Finally, the desert southwest of the U.S. exhibits more variability of aerosol species and is seasonal in nature, possible due to fire and desert dust events in the region.

Future studies should acknowledge that these analyses may be the first such analyses that attempt to understand global optical scattering and absorption trends. In general, aerosol optical trends followed emissions trends and the seasonality of aerosol sources. Since European sites did not show the same, strong, decreasing trends, this finding may be due to the lack of monitoring sites and datasets, the varied site characteristics, or the timing of implementation of emissions reductions. Because only 24 datasets were available for use, future studies could benefit from more global representation. Although the U.S. trends correspond with the reduction in PM and sulfur dioxide emissions, many more variable factors could be considered for future studies, including transport patterns and particle transformation.

References / Author affiliations

A full reference list and author affiliations can be obtained from the complete paper: Atmospheric Chemistry and Physics Discussions, 12, 20785-20848, 2012, and available at *http://www.atmos-chem-phys-discuss.net/12/20785/2012/acpd-12-20785-2012.pdf*.

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 3rd Quarter 2012 are:

Aerosol (Channel A) - 47% of all sites

Acadia	Great Sand Dunes	Proctor Research Cntr.
Barrier Lake	Great Smoky Mtns.	Queen Valley
Birmingham	Hawaii Volcanoes	Redwood
Blue Mounds	Hercules-Glades	Rocky Mountain
Boulder Lake	Hoover	Saguaro West
Bridger	Ike's Backbone	San Gabriel
Brigantine	Indian Gardens	Sawtooth
Caney Creek	Isle Royale	Seney
Canyonlands	Joshua Tree	Simeonof
Cape Cod	Kaiser	Snoqualamie Pass
Cape Romain	Lava Beds	St. Marks
Capitol Reef	Londonderry	Starkey
Cedar Bluff	Makah	Stilwell
Chassahowitzka	Mesa Verde	Sycamore Canyon
Cloud Peak	Mohawk Mountain	Tallgrass
Denali	Monture	Theodore Roosevelt
Ellis	Mount Hood	Three Sisters
Flat Tops	Mount Rainier	Trapper Creek-Denali
Flathead	North Cascades	Tuxedni
Fresno	Northern Cheyenne	UL Bend
Frostburg Reservoir	Organ Pipe	Upper Buffalo
Gates of the Arctic	Pack Monadnock	White River
Glacier	Phoenix	Wichita Mountain
Grand Canyon	Pinnacles	Yosemite
Great Gulf	Point Reyes	Zion Canyon
Great River Bluffs		

Nephelometer - 47% of all sites

Dysart	Hance	Rocky Mountain
Estrella	Indian Gardens	Vehicle Emissions
Great Basin	Mount Rainier	

Sites that achieved at least 95% data collection for 3rd Quarter 2012 are:

Aerosol (Channel A) - 22% of all sites

Big Bend	El Dorado Springs	Puget Sound
Bondville	Everglades	Saguaro
Boundary Waters	Gila	Salt Creek
Bridgton	Guadalupe Mtns.	Shamrock Mines
Bryce Canyon	Jarbidge	Sierra Ancha
Cabinet Mountains	Kalmiopsis	Thunder Basin
Chiricahua	Linville Gorge	Viking Lake
Columbia Gorge East	Mammoth Cave	Virgin Islands
Crescent Lake	Martha's Vineyard	Voyageurs
Dolly Sods	Medicine Lake	White Mountain
Dome Land	Pasayten	White Pass
Douglas	Presque Isle	Yellowstone

Nephelometer - 53% of all sites

Acadia	Glacier	Mount Rainier
Big Bend	Grand Teton	National Capital
Cape Romain	Great Smoky Mtns.	Shenandoah

Transmissometer - 100% of all sites

Bridger

Sites that achieved at least 90% data collection for 3rd Quarter 2012 are:

Aerosol (Channel A) - 15% of all sites

Badlands	Mingo	Sipsey
Bandelier	Moosehorn	Sula
Bliss	Mount Baldy	Swanquarter
Crater Lake	North Absaroka	Tonto
Egbert	Okefenokee	Trinity
Great Basin	Olympic	Weminuche
Hells Canyon	San Pedro Parks	Wheeler Peak
James River	Sequoia	Wind Cave
Lassen Volcanic		

Monitoring Site Assistance:

Aerosol sites: contact University of California-Davis telephone: 530/752-1123 (Pacific time)

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

Night sky camera *continued from page 3....*

The DSLR system incorporates special features targeted at capturing night sky images. Some of these special features include operating with very low power, controlling the system with an Android tablet, and using a very wide angle lens. The system is currently undergoing operational testing at ARS facilities.

The goal of nighttime capture is a two-step process: 1) to qualitatively document changes in the night sky conditions, and 2) to quantitatively measure the radiance field in the image. The quantitative measurements require the camera to undergo flat field correction to account for lens vignetting, and calibration to relate pixel values to radiance values.

It is expected the DSLR system will be deployed in the Yovimpa Point area at the southwest edge of Bryce Canyon National Park. This area is a popular scenic overlook for visitors and provides a tremendous view of most of the park. The system will operate on solar power, with cellular communications for image transfer and operational support.

The DSLR system is compatible with the existing NPS Webcamera network and captured images may be presented on the NPS Webcamera site (*http://www.nature.nps.gov/air/WebCams/index.cfm*) along with images from other NPS sites. System deployment is expected to occur in Spring 2013.

View from Yovimpa Point, in Bryce Canyon National Park, Utah. NPS Photo.

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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.

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Associate Membership in the IMPROVE Steering Committee requires operation of at least one IMPROVE protocol site, openly share data, and participate in technical review and oversight of the IMPROVE Program. Associate and International Associate Member representatives are:

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