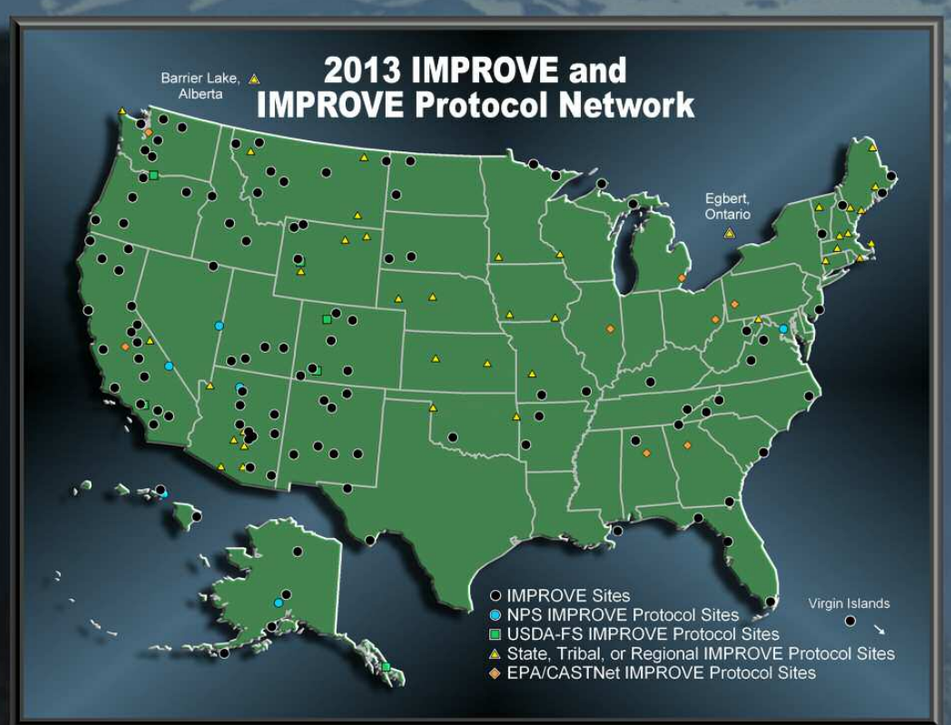

IMPROVE
Interagency Monitoring of Protected Visual Environments
CIRA
Colorado State University
2014 Calendar

IMPROVE Monitoring Update

IMPROVE
Interagency Monitoring of Protected Visual Environments

The IMPROVE (Interagency Monitoring of Protected Visual Environments) 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.

Sampling began in March 2013 at a new site on Baengnyeong Island, South Korea, the first IMPROVE site in Asia. The site is located on the grounds of the Baengnyeong Island Atmospheric Research Center, a facility operated by the National Institute of Environmental Research (NIER), a division of the Korea Ministry of Environment which provides the funding for operating this site. Aerosol sampling at Baengnyeong Island is intended to characterize regional air quality to the northwest of Seoul, approximately halfway along a trajectory between Seoul and Beijing, China. Baengnyeong Island is the westernmost point of South Korea, located over 125 miles (over 200 km) west of Seoul. The island is located off the southwestern tip of North Korea, just 10.5 miles (17 km) from the North Korean mainland. The monitoring site is well-removed from major emission sources and thus should be representative of the region. The island has fewer than 5,000 permanent residents plus a roughly equivalent number of South Korean military personnel.



Sampling Protocol Changes for Quartz Field Blanks

In 2013, UC Davis IMPROVE staff changed the sampling protocol for quartz field blanks. Previously, two back-to-back (double) quartz filters were installed in a sample cartridge. The new protocol has only one quartz filter blank installed in the sample cartridge. The sampling schedule for IMPROVE sites that have quartz field blanks has not changed. A single quartz field blank mimics the single quartz filters used in sampling at all except the 13 sites that have backup filters for artifact correction. Single blank quartz filters collect about 40% more total organic carbon (TOC) than either the front or back double quartz filters, thus a single quartz field blank is more representative of network samples. The new protocol will also decrease analytical costs because only one blank will be analyzed instead of two.

Site Status Updates in 2013

A maintenance crew discovered a problem with a module installation at WICA1 in the 2nd quarter. An operator replaced a module in Oct. 2012 to resolve some equipment problems, but the inlet was not seated properly inside the module; as a result, air was being pulled from inside the shelter instead of outside. Luckily, this site has a collocated module that can be used to replace the routine D module data. One other site, LOST1, also failed the Regional Haze Rule (RHR) criteria in a prior quarter.

No additional sites failed the RHR completeness criteria in the 3rd quarter. Chronic problems were discovered at three sites during the biannual maintenance visits: QUCI was missing stack inlet caps, the FOPE1 PM_{10} (D) module flow rate was 15% below its set point, and the NOCH1 PM_{10} (D) module flow rate was 26% below its set point. The impacts of these problems will be evaluated during data validation after the filters are analyzed.

Thanks to those of you who have met maintenance crews at the sites this summer. Due to budget constraints, our maintenance trips have been cut to every other year, so they're only visiting half the sites each year. As a result, there is a greater dependence on local contacts to catch problems. Please let UC Davis know if you are having any problems at your site.

Special thanks to the U.S. federal operators who modified their schedules to change samples immediately before and after the federal government shutdown to minimize sample losses.

January

You have to hold yourself accountable for your actions, and that's how we're going to protect the earth.
– Julia Butterfly Hill

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Dec 2013 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 Feb 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28			**1** *1 Julian day* New Year's Day	**2** *2* IMPROVE particle sampling day	**3** *3*	**4** *4*
5 *5* IMPROVE particle sampling day	**6** *6*	**7** *7* Change IMPROVE particle cartridges.	**8** *8* IMPROVE particle sampling day	**9** *9*	**10** *10*	**11** *11* IMPROVE particle sampling day
12 *12*	**13** *13*	**14** *14* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**15** *15*	**16** *16*	**17** *17* IMPROVE particle sampling day	**18** *18*
19 *19*	**20** *20* Martin Luther King, Jr. Day IMPROVE particle sampling day	**21** *21* Change IMPROVE particle cartridges.	**22** *22*	**23** *23* IMPROVE particle sampling day	**24** *24*	**25** *25*
26 *26* IMPROVE particle sampling day	**27** *27*	**28** *28* Change IMPROVE particle cartridges.	**29** *29* IMPROVE particle sampling day	**30** *30*	**31** *31*	**UC Davis**: *Sampler*: General Lab (530) 752-1123 **ARS**: *Optical*: Carter Blandford or Karen Rosener *Photography*: Karen Fischer (970) 484-7941

Operator Involvement -- The Key to Network Success

The Network Sampler and Unforeseen Events

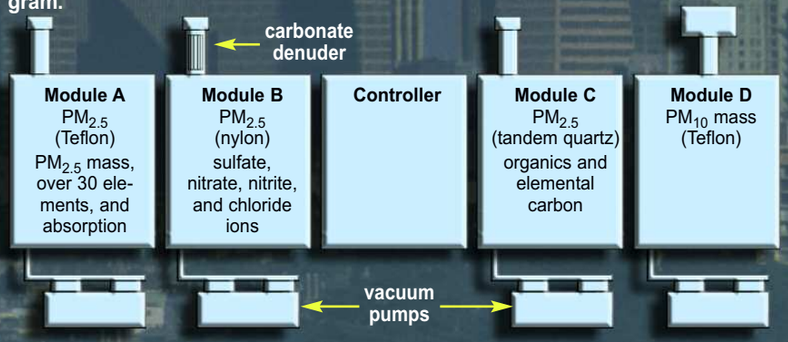
IMPROVE
Interagency Monitoring of Protected Visual Environments

IMPROVE Aerosol Monitor

The IMPROVE sampler is designed to obtain a complete signature of the composition of airborne particles affecting visibility. Four independent sampling modules measure mass, chemical elements, sulfate, nitrate, organics, and elemental carbon. The samplers run for 24 hours every third day, collecting the particulate matter on filters. These filters are retrieved weekly and sent to contracted laboratories for analysis.

Modules A, B, and C collect $PM_{2.5}$ (fine) particles on Teflon, nylon, and quartz filters, respectively. Module D, on the right, has a larger inlet head that collects both $PM_{2.5}$ (fine) and PM_{10} (coarse) particles on a Teflon filter. The inlets are normally 24 inches apart, with a controller module in the center that has no inlet. IMPROVE samples are intended to be collected under conditions as close to ambient temperature as possible.

Particle data are available on the IMPROVE Web site at http://vista.cira.colostate.edu/improve/, where you can also get more information on the IMPROVE program.



IMPORTANT: Valid Measurements

Under the Regional Haze Rule, valid measurements require

- 75% of the possible samples for the year,
- 50% of the possible samples for each calendar quarter be complete, and
- no more than 10 consecutive sampling periods be missing.

Catastrophic Events

Catastrophic events, by definition, are sudden natural or human-caused situations where damage and destruction may occur without prior knowledge or preparation. Some examples of catastrophic events include severe thunderstorms and lightning strikes; blizzards and snowstorms; sandstorms; hurricanes, typhoons, tornadoes, and other high winds; floods; heat waves; wildfires; mudslides; hail storms; cold spells; ice storms; earthquakes; and volcanic eruptions. IMPROVE sampling sites have been and will continue to be impacted by catastrophic events.

In Case of Emergency

Wildfires occur every year throughout the United States. These fires can occur in clusters and are often regional in scope, blanketing hundreds of square miles with smoke for days at a time. Many IMPROVE sites are located in the forests and grasslands where these fires occur, so IMPROVE samplers can be impacted by smoke from the fires. Moderate amounts of particulate material collected during these events provide interesting insights into the behavior and composition of wildfire smoke. But when the smoke becomes too thick, the sampler clogs and data are lost for those days.

Suggestions for operators in case of a foreseen emergency:

- Operators should first call the UC Davis Air Quality Group (AQG) lab and inform personnel of the situation. If they cannot contact a technician, they should leave a message with pertinent information such as the operator's name, the site name (printed on the side of each filter box), the operator's phone number, and a brief description of the situation.

- Operators should assess the situation. If there is any possibility of danger, they should not attempt to visit the site. If it is safe to approach the site, it is preferred that the equipment be removed and stored in a secure and dry area. Note that in order to remove the equipment, a 5/32" and/or 1/8" hex L-key (Allen wrench) is required. The equipment is very heavy; modules weigh 45 lbs, and pumps weigh 22 lbs, so operators should be careful when lifting them out. The following steps are to ensure safe removal of the equipment:

  1. If time allows, run through final filter readings as if it were a normal Tuesday sample change. Leave the filters in the modules; they will provide support to the inner structure during transportation.
  2. After taking final readings, disconnect the power cord to the controller.
  3. If the site's breaker is accessible, turn it off.
  4. Disconnect all cables and vacuum hoses from underneath the modules and controller.
  5. Remove stacks by loosening the stack collar. The D module stack will have an internal brace that needs to be loosened with the 5/32" Allen wrench.
  6. Use the Allen wrench to free the module from the top bracket. This will allow the module to swing down and come off the wall. Modules are heavy (45 lbs), so be prepared for the weight.
  7. Remove the pumps by first disconnecting all vacuum hoses and power cables.
  8. If time allows, remove all cables and hoses. Some cables may be anchored to the stand or shed.

February

I feel more confident than ever that the power to save the planet rests with the individual consumer.
– Denis Hayes

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
◆ Electrical connections (e.g., extension cords) exposed to wet conditions should be GFCI protected. ◆ Watch for frost on the inlets.		Jan 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Mar 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31			**1** *32 Julian day* IMPROVE particle sampling day
2 *33* Groundhog Day	**3** *34*	**4** *35* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**5** *36*	**6** *37*	**7** *38* IMPROVE particle sampling day	**8** *39*
9 *40*	**10** *41* IMPROVE particle sampling day	**11** *42* Change IMPROVE particle cartridges.	**12** *43* Lincoln's Birthday	**13** *44* IMPROVE particle sampling day	**14** *45* Valentine's Day	**15** *46*
16 *47* IMPROVE particle sampling day	**17** *48* Presidents' Day	**18** *49* Change IMPROVE particle cartridges.	**19** *50* IMPROVE particle sampling day	**20** *51*	**21** *52*	**22** *53* Washington's Birthday IMPROVE particle sampling day
23 *54*	**24** *55*	**25** *56* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**26** *57* Grand Canyon National Park established, 1919	**27** *58*	**28** *59* IMPROVE particle sampling day	**UC Davis**: *Sampler*: General Lab (530) 752-1123 **ARS**: *Optical*: Carter Blandford or Karen Rosener *Photography*: Karen Fischer (970) 484-7941

Operator Involvement -- The Key to Network Success

Of Interest to Operators...

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IMPROVE field operations benefit from an understanding of the issues identified during the field audit process. The issues outlined here are under site operator control, and awareness of these potential problems will improve overall data quality, decrease data loss, and aid troubleshooting field operations.

Operator Observations

- Inspect sampler inlets every three months for insect infestations in the sampler inlet, flies in the module or released from cassette upon removal, and spider webs.
- Rodent infestation may occur, especially in fall and winter. Check wires and tubing for damage.
- Verify that the calibration plug is seated (at bottom of T-fitting where the inlet tube enters) in every module. Check at each filter exchange.
- Check the temperature at each setup to assure it is within 10° C of outdoor temperature.
- Clocks should be reset when they vary by ±5 minutes or more.
- In November, December, and January, operators should call the UC Davis lab at 530-752-1123 to properly determine how the holidays will affect their sample change schedules in order to not lose samples.
- Periodically inspect the vacuum line for "rubbing spots". Pumps vibrate a lot and that means the vacuum lines also vibrate. If a vibrating line is touching another surface, it is likely the rubbing surface will eat away at the hose wall. Hoses are often found in this condition during UC Davis site visits. Call the lab and a replacement hose will be sent out quickly. Operators can reposition pumps so hoses don't touch corners.

Modules need to be kept clean and free of debris. The maintenance teams clean the enclosures (inside and out), but this is done only once a year. Operator help with this effort is appreciated.

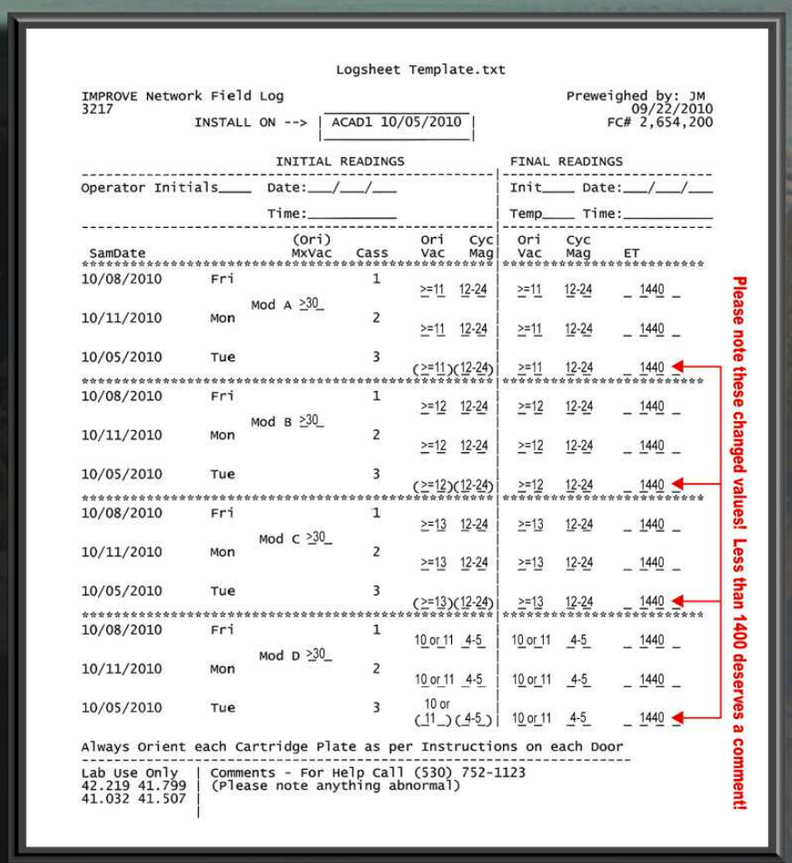
Checking Value Ranges and Reporting Problems

It is important to be mindful of the values that get written down on the log sheets and what those values mean. Past problems included recording a value of 10.0 for the MxVAC for a 5-week stretch without reporting the incident to UC Davis technicians. One of the pumps had failed but it was not discovered until 12 consecutive samples were lost.

The log sheet template is a guide to help operators recognize a problem that requires immediate attention. The values chosen are deliberately broad because there is no tight band that will represent all sites. The log sheet values are affected by different versions of electronic equipment, as well as the site's elevation. For example, most sites under 5,000 feet will have a MxVAC value of 40, which represents the maximum vacuum of an ideal pump. The same pump will have an optimum value of 32 if it is at 10,000 feet, like at Wheeler Peak, NM, or White River Natl. Forest, CO. For this reason a minimum value of 31 was chosen. The ET values are the same for all sites. "ET" means elapsed time in minutes. They should all be 1440, which corresponds to a 24-hour sampling period. The exception is position 3 (which is the sample that runs on Tuesdays), which can be shorter because operators typically interrupt this sample when they do their filter changes on Tuesdays.

Friendly Reminders

Samplers now run exclusively on standard time and should never be changed to DST. Also, please reference the sample log sheet every time you record filter readings and call the lab any time that values fall out of range or you notice anything odd with the system. The sample log sheet below can be e-mailed to you if you do not already have one.



Logsheet Template.txt

IMPROVE Network Field Log
3217

Preweighed by: JM
09/22/2010
FC# 2,654,200

INSTALL ON --> | ACAD1 10/05/2010 |

			INITIAL READINGS			FINAL READINGS			
Operator Initials____ Date:___/___/___ Time:_____						Init____ Date:___/___/___ Temp____ Time:_____			
SamDate		(Ori) MxVac	Cass	Ori Vac	Cyc Mag	Ori Vac	Cyc Mag	ET	
10/08/2010	Fri		1	>=11	12-24	>=11	12-24	1440	
	Mod A >30								
10/11/2010	Mon		2	>=11	12-24	>=11	12-24	1440	
10/05/2010	Tue		3	(>=11)	(12-24)	>=11	12-24	1440	
10/08/2010	Fri		1	>=12	12-24	>=12	12-24	1440	
	Mod B >30								
10/11/2010	Mon		2	>=12	12-24	>=12	12-24	1440	
10/05/2010	Tue		3	(>=12)	(12-24)	>=12	12-24	1440	
10/08/2010	Fri		1	>=13	12-24	>=13	12-24	1440	
	Mod C >30								
10/11/2010	Mon		2	>=13	12-24	>=13	12-24	1440	
10/05/2010	Tue		3	(>=13)	(12-24)	>=13	12-24	1440	
10/08/2010	Fri		1	10 or 11	4-5	10 or 11	4-5	1440	
	Mod D >30								
10/11/2010	Mon		2	10 or 11	4-5	10 or 11	4-5	1440	
10/05/2010	Tue		3	10 or (11)	(4-5)	10 or 11	4-5	1440	

Please note these changed values! Less than 1400 deserves a comment!

Always Orient each Cartridge Plate as per Instructions on each Door

Lab Use Only
42.219 41.799
41.032 41.507

Comments - For Help Call (530) 752-1123
(Please note anything abnormal)

March

I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait 'til oil and coal run out before we tackle that.
– Thomas Edison

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
◆ Watch for lightning damage. ◆ Check site conditions (e.g., a tree growing beyond acceptance criteria).		Feb 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	Apr 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30		◆ Electrical connections (e.g., extension cords) exposed to wet conditions should be GFCI protected. ◆ Watch for frost on the inlets.	**1** *60 Julian day* Yellowstone Natl. Park established, 1872
2 *61*	**3** *62* IMPROVE particle sampling day	**4** *63* Change IMPROVE particle cartridges.	**5** *64*	**6** *65* IMPROVE particle sampling day	**7** *66*	**8** *67*
9 *68* Daylight Savings Time begins Do not change sampler clock. IMPROVE particle sampling day	**10** *69*	**11** *70* Change IMPROVE particle cartridges.	**12** *71* IMPROVE particle sampling day	**13** *72*	**14** *73*	**15** *74* IMPROVE particle sampling day
16 *75*	**17** *76* St. Patrick's Day	**18** *77* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**19** *78*	**20** *79* Spring begins	**21** *80* IMPROVE particle sampling day	**22** *81*
23 *82*	**24** *83* IMPROVE particle sampling day	**25** *84* Change IMPROVE particle cartridges.	**26** *85*	**27** *86* IMPROVE particle sampling day	**28** *87*	**29** *88*
30 *89* IMPROVE particle sampling day	**31** *90*					

UC Davis: *Sampler*:
General Lab
(530) 752-1123

ARS: *Optical*:
Carter Blandford or
Karen Rosener
Photography:
Karen Fischer
(970) 484-7941

Operator Involvement -- The Key to Network Success

Filters

IMPROVE
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The first step in correctly diagnosing and solving any problem is to call UCD's General Lab at 530-752-1123. No problem is too small, and a correct diagnosis is more likely to be made.

Has a filter or cartridge been dropped?

The cartridges are well protected, and unless the operator is physically forcing air through the media, there should be no immediate problem. Pay careful attention to any fluctuation in the normal readings on that particular set of filters. As with any significant event, note it on the log sheet and detail what occurred. Notify UCD about any questions or concerns.

What if the filter gets wet?

Although this can significantly affect the sample, UCD may or may not be able to send a replacement. Call the lab so that UCD can deal with it properly, and note it on the log sheet.

Missed changing filters on the regular Tuesday?

Immediately call UCD to get instructions before proceeding with the sample change. Experienced operators should still call UCD to advise of any deviation in the sample changing schedule.

*** If there are remaining sampling days in the week:**
Remove the exposed filters as would normally be done, and put in the clean filters that were to have been installed on the last change day. Make a note on the log sheet.

*** If the week is completely missed:**
Remove the exposed filters as would normally be done, but do not put in the filters for the missed change day. Keep these in the shipping box, and send them back to UCD when both weeks in that box have passed. Install the appropriate filters for the current week. Make a note on the log sheet of the filters that were not installed.

Trouble with the "red button"-controlled motors?

Sometimes when the weather turns cold, the electric motor that raises and lowers the solenoids works very slowly. If this occurs, or if the red buttons fail to work for any reason, follow the steps on the right.

Modules A-C:
The motor is located in the top right area.

1. Disengage motor by gently pushing down on the top of the motor.

2. "Lockout" the motor by rotating it toward the solenoids.

3. Raise and lower the solenoids by turning the handwheel at the top of the module.

Module D:
The motor is located in the bottom left area.

1. Disengage motor by gently pushing up on the bottom of the motor.

2. "Lockout" the motor by rotating it toward the solenoids.

3. Raise and lower the solenoids by turning the handwheel at the bottom of the module.

For questions or problems ...

When a problem is identified with the sampler, first note the issue on the logsheet. The first step in correctly diagnosing and solving any problem is to call the UC Davis sample-handling laboratory at 530-752-1123 (fax: 530-752-4107; e-mail: fieldops@crocker.ucdavis.edu). If possible, call from the site to facilitate troubleshooting.

April

We have to cultivate contentment with what we have. We really don't need much. ... Cultivate generosity. Delight in giving. Learn to live lightly. In this way, we can begin to transform what is negative into what is positive. This is how we start to grow up. – Jetsunma Tenzin Palmo

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
UC Davis: *Sampler*: General Lab (530) 752-1123 **ARS**: *Optical*: Carter Blandford or Karen Rosener *Photography*: Karen Fischer (970) 484-7941	◆ Check for insect infestations in spring and summer (e.g., mud daubers in sampler inlet and spider webs). ◆ Check for melting ice on tops of sampler modules.	**1** *91 Julian day* Change IMPROVE particle cartridges.	**2** *92* IMPROVE particle sampling day	**3** *93*	**4** *94*	**5** *95* IMPROVE particle sampling day
6 *96*	**7** *97*	**8** *98* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**9** *99*	**10** *100*	**11** *101* IMPROVE particle sampling day	**12** *102*
13 *103*	**14** *104* IMPROVE particle sampling day	**15** *105* Change IMPROVE particle cartridges.	**16** *106*	**17** *107* IMPROVE particle sampling day	**18** *108*	**19** *109*
20 *110* IMPROVE particle sampling day	**21** *111*	**22** *112* Change IMPROVE particle cartridges.	**23** *113* IMPROVE particle sampling day	**24** *114*	**25** *115*	**26** *116* IMPROVE particle sampling day
27 *117*	**28** *118*	**29** *119* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**30** *120* Arbor Day			

Mar 2014

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30	31					

May 2014

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25	26	27	28	29	30	31

Operator Involvement -- The Key to Network Success

The Regional Haze Rule and WRAP's Progress Report

IMPROVE
Interagency Monitoring of Protected Visual Environments

Background

In amendments to the Clean Air Act in 1977, Congress set a national goal for visibility as "the prevention of any future and the remedying of any existing impairment of visibility in mandatory Class I federal areas in which impairment results from manmade air pollution." The Environmental Protection Agency (EPA) was required to issue regulations to assure "reasonable progress" toward meeting the national goal.

In 1988 the EPA, the states, and the federal land managers (National Park Service, USDA Forest Service, US Fish and Wildlife Service, and Bureau of Land Management) began monitoring fine particle concentrations and visibility in 30 Class I areas across the country under the IMPROVE program. In 1990 Congress amended the Clean Air Act, putting additional emphasis on regional haze issues. In 1997 the EPA proposed regional haze regulations in conjunction with new national ambient air quality standards for fine particulate matter ($PM_{2.5}$). Final regional haze regulations were promulgated in 1999 under the Regional Haze Rule, which set a national goal of reaching natural visibility conditions by 2064 and established a time line for reaching that goal.

The Rule

The haze rules require states to establish and update baseline, natural, and current visibility conditions where baseline conditions represent visibility at the time the rules are established, between 2000 and 2004; natural conditions represent visibility in the absence of human-caused impairment; and current conditions represent the most recent multiyear average and reflect progress from the baseline period. (Current conditions are updated for each State Implementation Plan [SIP] revision.)

Natural Aerosol Conditions - Default Values

The Regional Haze Rule provides initial default values for natural haze conditions. The default haze value for the West is 8 deciviews, while for the East it is 11 deciviews. This is obtained by estimating the natural concentrations of SO_4, EC, OC, NO_3, and fine and coarse soil and weighting each aerosol component by corresponding extinction efficiencies (Trijonis, 1990).

The WRAP Regional Haze Rule Progress Report Support Document

by C. Archuleta[1], T. Moore[2], E. Vanden Hoek[1], and J. Adlhoch[1]
([1]Air Resource Specialists, Inc.; Fort Collins, CO, and [2]WESTAR Council, Western Regional Air Partnership; Seattle, WA)

A primary purpose of visibility monitoring for the IMPROVE Network is to measure visibility conditions in support of the United States Environmental Protection Agency's (EPA's) 1999 Regional Haze Rule (RHR), which protects visibility conditions in the nation's largest national parks and wilderness areas. For the RHR, visibility impairment is tracked using a haze index in units of deciviews, which is related to the sum of visibility impairment from individual aerosol species as measured by IMPROVE Network monitors. Pursuant to the RHR, states are required to submit implementation plans that summarize existing conditions and identify goals and strategies for visibility improvement. States are required to revise these implementation plans every ten years and submit progress reports at interim points between implementation plan submittals. The first RHR implementation plans were due in 2007, and the first interim progress reports come due at various times in the 2012-2018 timeframe.

In preparation for the submittal of the first of these interim progress reports, the Western Regional Air Partnership (WRAP), in cooperation with representatives from the fifteen member states in the WRAP region, recently prepared a technical support document intended to provide the technical basis for western states to assess progress toward goals as defined in their initial RHR implementation plans. It was reported that most WRAP Class I areas (CIAs) showed improved visibility conditions on the worst days, and nearly all sites showed improvement on the best days. Although the RHR prescribes tracking visibility in terms of deciviews, the support document also looked at changes in individual aerosol species measured by the IMPROVE Network. Comparisons of baseline and progress period emissions inventories are also presented in the progress report. Some specific observations were as follows:

- Most sites that did not show improved deciview conditions on the worst days were affected by large particulate organic matter measurements related to wildland fire.
- Ammonium nitrate, in most cases, showed the largest decreases in five-year averages and the largest decreasing annual trends. This was consistent with mobile source inventory comparisons that showed large decreases in oxides of nitrogen, which are among the precursors for ammonium nitrate particulate formation.
- In many of the plains states, annual averages showed decreasing trends, but 5-year averages increased due to high outlier measurements. Sulfur dioxide emissions, which are precursors for ammonium sulfate particle formation, showed decreases in most cases, especially from electric generating units and other point sources.
- In Hawaii, dramatic increases in ammonium sulfate measurements were related to natural emissions, with increased volcanic emissions accounting for most of the sulfur dioxide inventoried.

More detailed regional, state, and Class I area specific summaries are provided in the full report on the WRAP Web site at http://www.wrapair2.org/RHRPR.aspx. These summaries are also supported by interactive tools available from the online WRAP Technical Support System (TSS) at http://vista.cira.colostate.edu/tss/. For more information, contact Tom Moore at WESTAR Council, WRAP Air Quality Program, at 970-491-8837, or by e-mail at tmoore@westar.gov, or contact Cassie Archuleta at Air Resource Specialists at 970-484-7941, or by e-mail at carchuleta@air-

May

Ideals are like stars: you will not succeed in touching them with your hands, but like the seafaring man on the desert of waters, you choose them as your guides, and following them you reach your destiny.
– Carl Schurz

UC Davis: *Sampler*:
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ARS: *Optical*:
Carter Blandford or
Karen Rosener
Photography:
Karen Fischer
(970) 484-7941

Apr 2014

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27	28	29	30			

Jun 2014

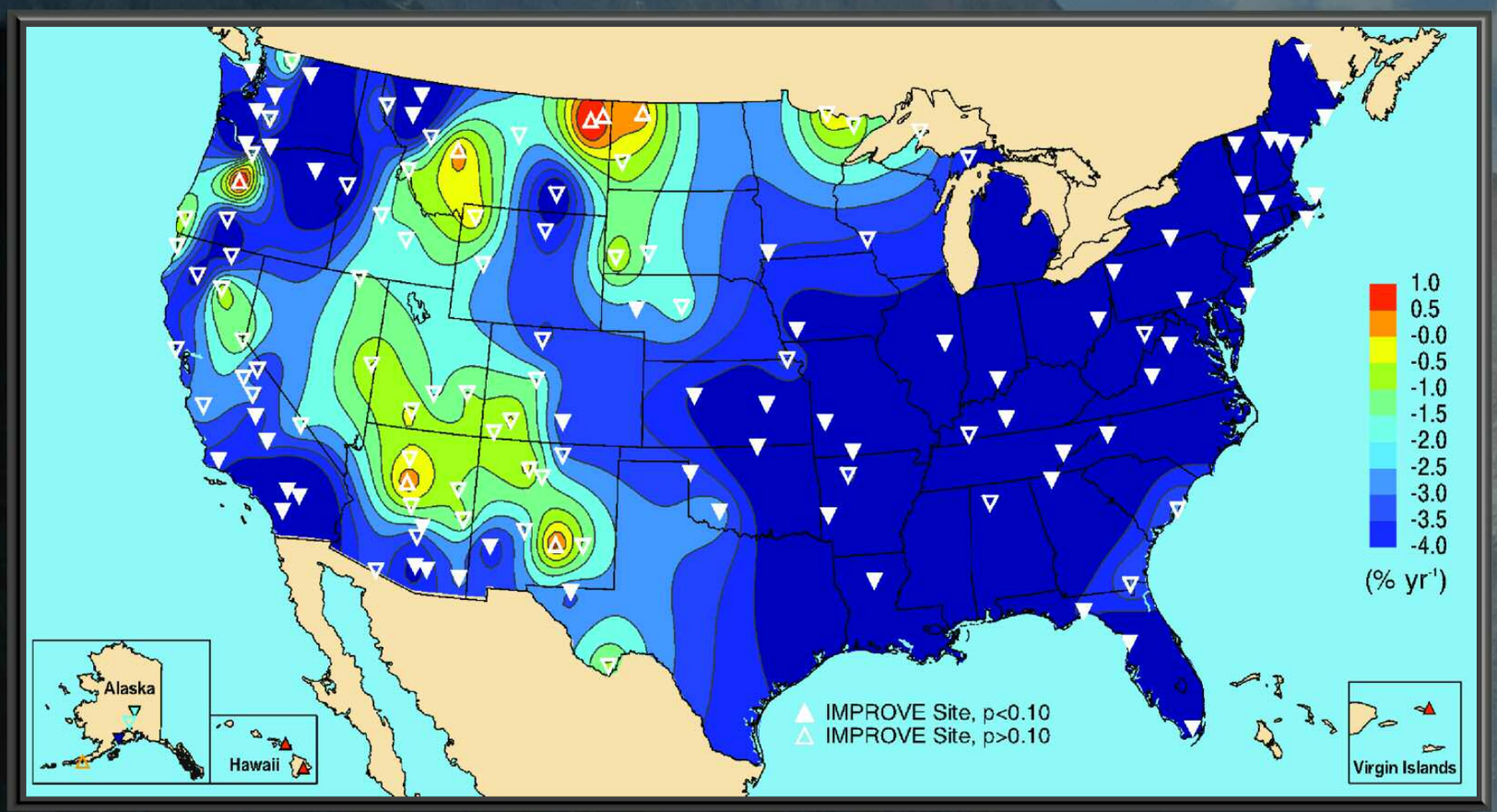
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 *121 Julian day*	**2** *122* IMPROVE particle sampling day	**3** *123*
4 *124*	**5** *125* IMPROVE particle sampling day	**6** *126* Change IMPROVE particle cartridges.	**7** *127*	**8** *128* IMPROVE particle sampling day	**9** *129*	**10** *130*
11 *131* Mother's Day IMPROVE particle sampling day	**12** *132*	**13** *133* Change IMPROVE particle cartridges.	**14** *134* IMPROVE particle sampling day	**15** *135*	**16** *136*	**17** *137* Armed Forces Day IMPROVE particle sampling day
18 *138*	**19** *139*	**20** *140* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**21** *141*	**22** *142*	**23** *143* IMPROVE particle sampling day	**24** *144*
25 *145*	**26** *146* Memorial Day (Observed) IMPROVE particle sampling day	**27** *147* Change IMPROVE particle cartridges.	**28** *148*	**29** *149* IMPROVE particle sampling day	**30** *150*	**31** *151*

Operator Involvement -- The Key to Network Success

Trends: b_{ext} (Light Extinction)

IMPROVE
Interagency Monitoring of Protected Visual Environments



IMPROVE 2000–2011 trends (% yr^{-1}) in the mean 20% haziest ambient light extinction coefficient (b_{ext} at 550 nm). Triangles correspond to location of IMPROVE sites; upward-pointing triangles correspond to increased b_{ext} and vice versa. Significance levels (p) less than 0.10 are considered significant (filled triangles). Regional differences in trends are quite evident. The haziest conditions in the East decreased at a rate of approximately -4% yr^{-1}, less so in the West (0 to -2% yr^{-1}). A few sites in Oregon, the Southwest, and the northern Great Plains experienced positive, although insignificant, trends. The greatest improvement in the haziest conditions occurred at Cohutta, GA (-8.6% yr^{-1}, p=0.05), while the haziest b_{ext} significantly increased at Hawaii Volcanoes, HI, at a rate of 9.4% yr^{-1} (p=0.07).

June

The purpose of life is not to be happy. It is to be useful, to be honorable, to be compassionate, to have it make some difference that you have lived and lived well.
– Ralph Waldo Emerson

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 *152 Julian day* IMPROVE particle sampling day	**2** *153*	**3** *154* Change IMPROVE particle cartridges.	**4** *155* IMPROVE particle sampling day	**5** *156* National Trails Day	**6** *157*	**7** *158* IMPROVE particle sampling day
8 *159*	**9** *160*	**10** *161* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**11** *162*	**12** *163*	**13** *164* IMPROVE particle sampling day	**14** *165* Flag Day
15 *166* Father's Day	**16** *167* IMPROVE particle sampling day	**17** *168* Change IMPROVE particle cartridges.	**18** *169*	**19** *170* IMPROVE particle sampling day	**20** *171* Summer begins	**21** *172*
22 *173* IMPROVE particle sampling day	**23** *174*	**24** *175* Change IMPROVE particle cartridges.	**25** *176* IMPROVE particle sampling day	**26** *177*	**27** *178*	**28** *179* IMPROVE particle sampling day
29 *180*	**30** *181*					

- Watch for lightning damage.
- Check site conditions (e.g., a tree growing beyond acceptance criteria).

May 2014

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
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18	19	20	21	22	23	24
25	26	27	28	29	30	31

Jul 2014

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

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Photography:
Karen Fischer
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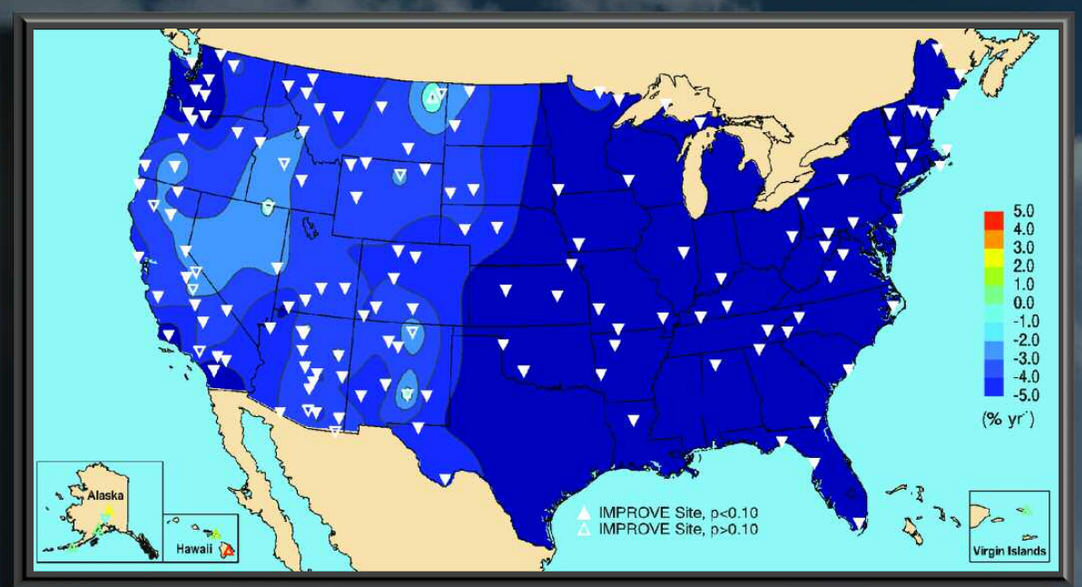
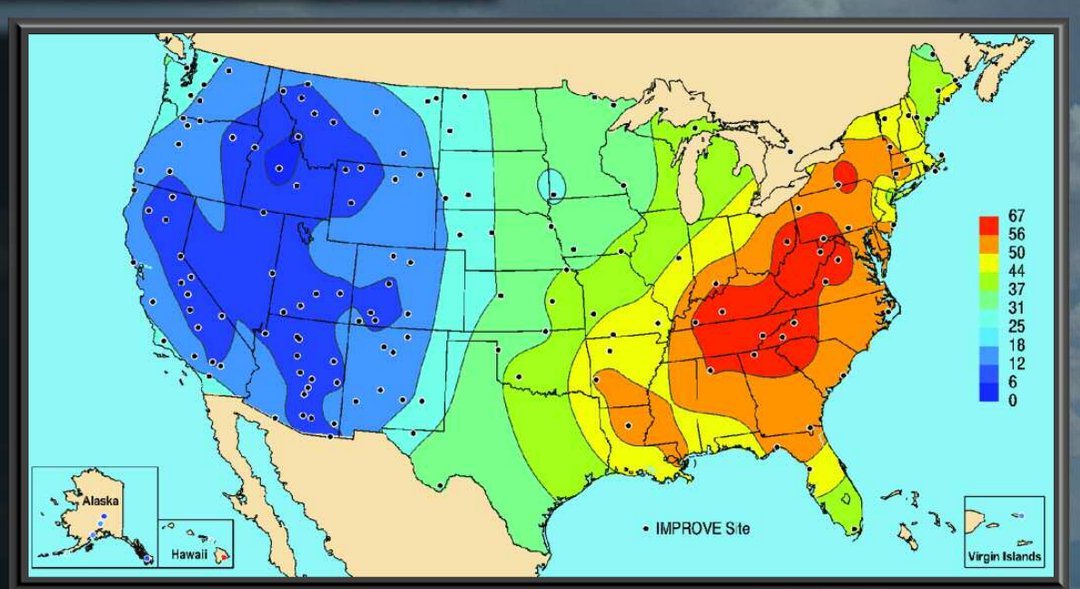
Operator Involvement -- The Key to Network Success

Trends: Ammonium Sulfate

IMPROVE
Interagency Monitoring of Protected Visual Environments





Trends over time of b_{ext} (visibility) are a result of changes over time of those particle species that contribute to b_{ext}. The first graph shows trends in annual mean ammonium sulfate as a percent change in composition per year from 2000 to 2012 while the second graph shows the fraction of total annual mean extinction (from 2005 to 2009) that can be attributed to ammonium sulfate.

July

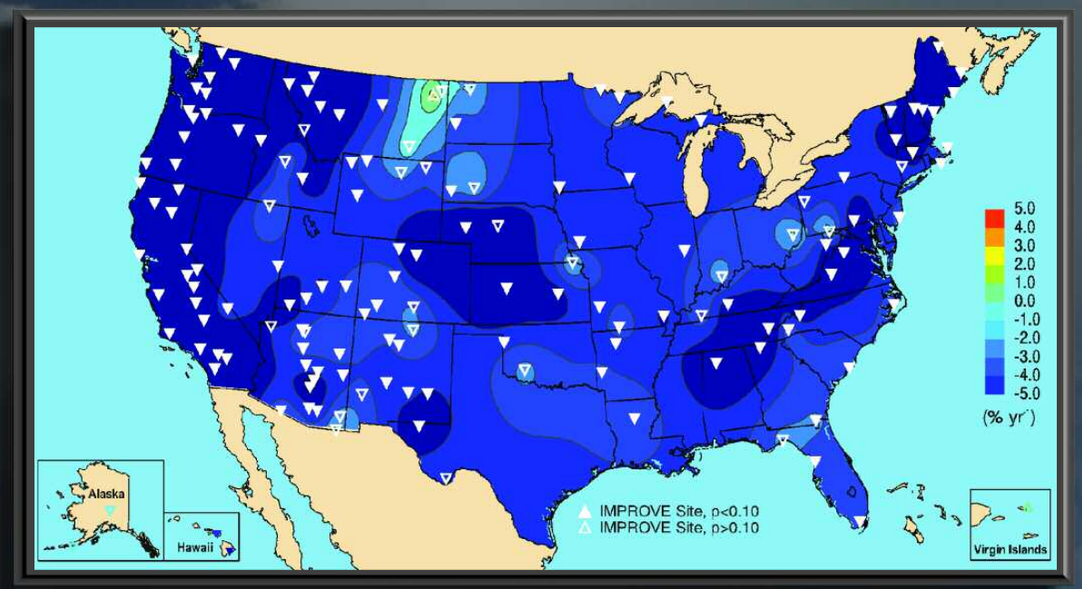
Here is your country. Cherish these natural wonders, cherish the natural resources, cherish the history and romance as a sacred heritage, for your children and your children's children. Do not let selfish men or greedy interests skin your country of its beauty, its riches, or its romance. – Theodore Roosevelt

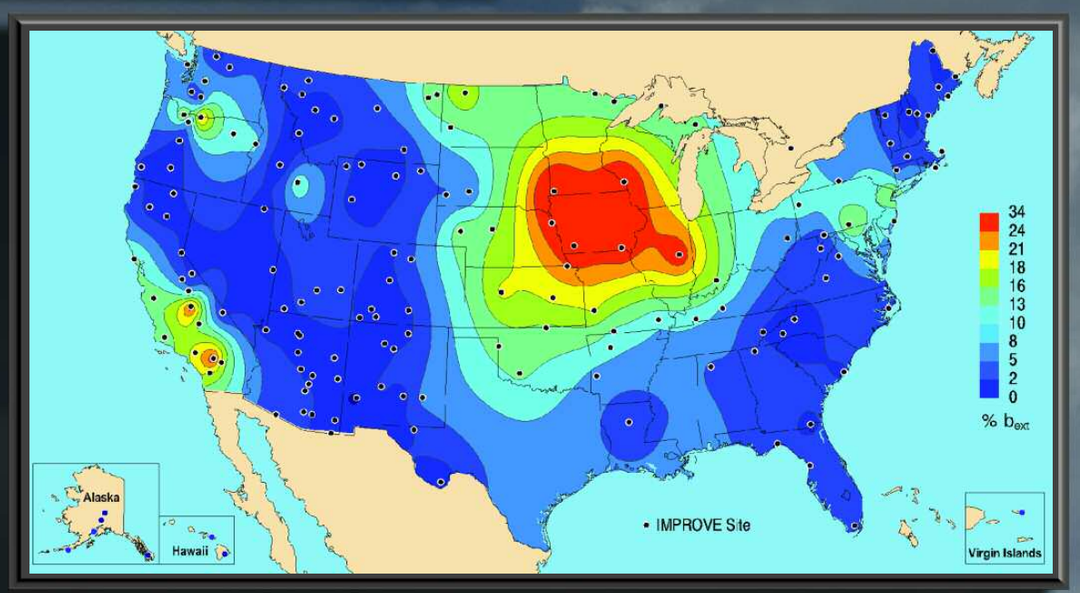
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Jun 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30		**1** *182 Julian day* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**2** *183*	**3** *184*	**4** *185* Independence Day IMPROVE particle sampling day	**5** *186*
6 *187*	**7** *188* IMPROVE particle sampling day	**8** *189* Change IMPROVE particle cartridges.	**9** *190*	**10** *191* IMPROVE particle sampling day	**11** *192*	**12** *193*
13 *194* IMPROVE particle sampling day	**14** *195*	**15** *196* Change IMPROVE particle cartridges.	**16** *197* National Parks Day IMPROVE particle sampling day	**17** *198*	**18** *199*	**19** *200* IMPROVE particle sampling day
20 *201*	**21** *202*	**22** *203* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**23** *204*	**24** *205*	**25** *206* IMPROVE particle sampling day	**26** *207*
27 *208*	**28** *209* IMPROVE particle sampling day	**29** *210* Change IMPROVE particle cartridges.	**30** *211*	**31** *212* IMPROVE particle sampling day	Aug 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	

Operator Involvement -- The Key to Network Success

Trends: Ammonium Nitrate

IMPROVE
Interagency Monitoring of Protected Visual Environments





Trends over time of b_{ext} (visibility) are a result of changes over time of those particle species that contribute to b_{ext}. The first graph shows trends in annual mean mass ammonium nitrate as a percent change in mass per year from 2000 to 2012 while the second graph shows the fraction of total extinction that can be attributed to ammonium nitrate.

August

The ultimate test of man's conscience may be his willingness to sacrifice something today for future generations whose words of thanks will not be heard.
– Gaylord Nelson

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
◆ Watch for lightning damage. ◆ Check site conditions (e.g., a tree growing beyond acceptance criteria).	Jul 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Sep 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	◆ Electrical connections (e.g., extension cords) exposed to wet conditions should be GFCI protected. ◆ Watch for frost on the inlets.	**1** *213 Julian day*	**2** *214*
3 *215* IMPROVE particle sampling day	**4** *216*	**5** *217* Change IMPROVE particle cartridges.	**6** *218* IMPROVE particle sampling day	**7** *219*	**8** *220*	**9** *221* IMPROVE particle sampling day
10 *222*	**11** *223*	**12** *224* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**13** *225*	**14** *226*	**15** *227* IMPROVE particle sampling day	**16** *228*
17 *229*	**18** *230* IMPROVE particle sampling day	**19** *231* Change IMPROVE particle cartridges.	**20** *232*	**21** *233* IMPROVE particle sampling day	**22** *234*	**23** *235*
24 *236* IMPROVE particle sampling day	**25** *237*	**26** *238* Change IMPROVE particle cartridges.	**27** *239* IMPROVE particle sampling day	**28** *240*	**29** *241*	**30** *242* IMPROVE particle sampling day
31 *243*						

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Photography:
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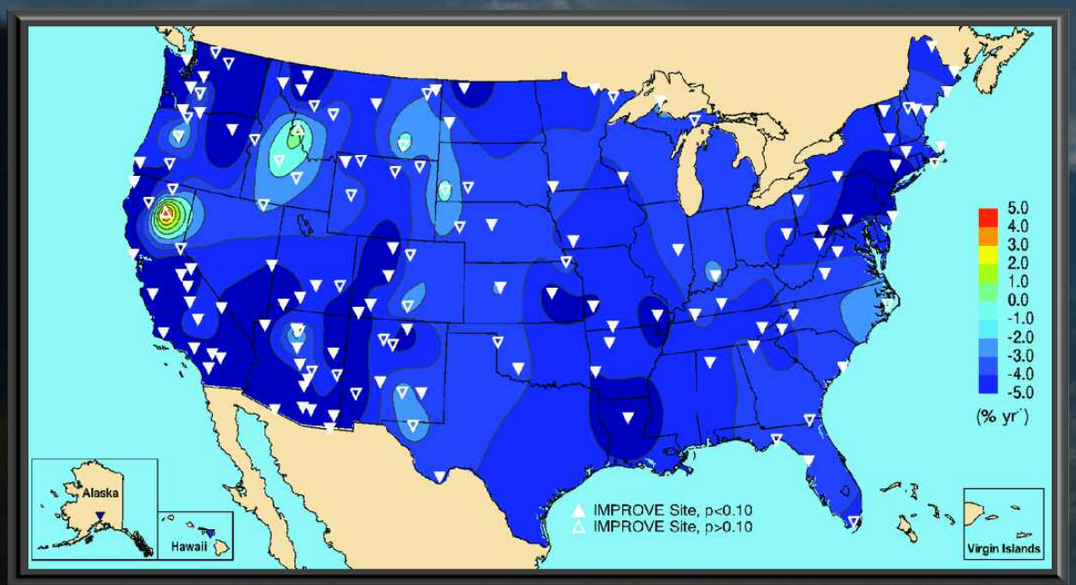
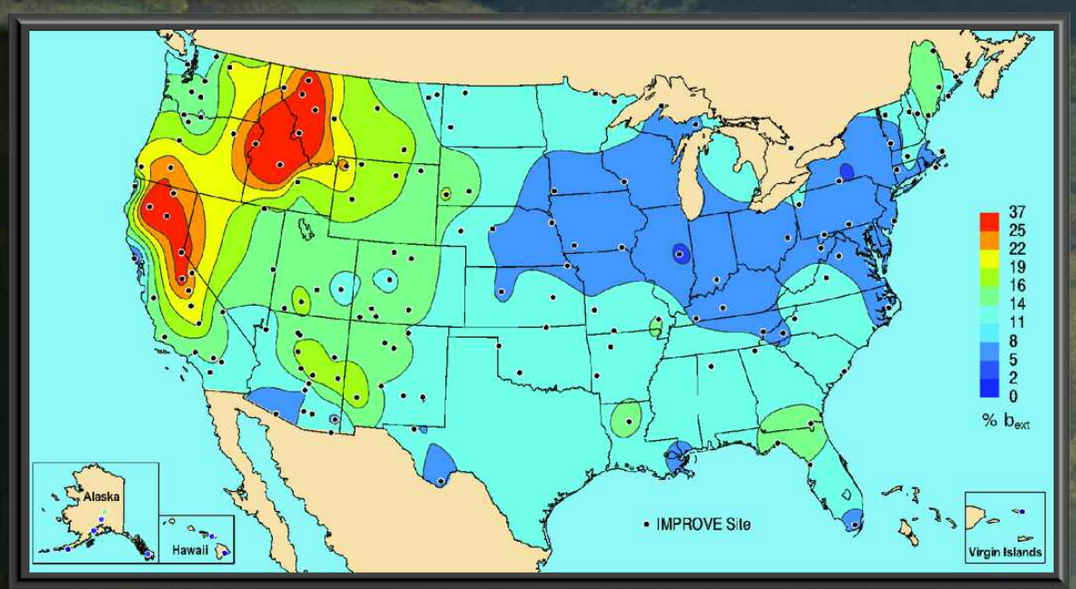
Operator Involvement -- The Key to Network Success

Trends: Organic Matter

IMPROVE
Interagency Monitoring of Protected Visual Environments





Trends over time of b_{ext} (visibility) are a result of changes over time of those particle species that contribute to b_{ext}. The first graph shows trends in particulate organic matter (POM) mass as a percent change per year from 2000 to 2012 while the second graph shows the fraction of total extinction that can be attributed to POM.

September

Waste is a tax on the whole people.
– Albert W. Atwood

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
◆ Watch for lightning damage. ◆ Check site conditions (e.g., a tree growing beyond acceptance criteria).	**1** *244 Julian day* Labor Day	**2** *245* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**3** *246*	**4** *247*	**5** *248* IMPROVE particle sampling day	**6** *249*
7 *250*	**8** *251* IMPROVE particle sampling day	**9** *252* Change IMPROVE particle cartridges.	**10** *253*	**11** *254* IMPROVE particle sampling day	**12** *255*	**13** *256*
14 *257* IMPROVE particle sampling day	**15** *258*	**16** *259* Change IMPROVE particle cartridges.	**17** *260* IMPROVE particle sampling day	**18** *261* National Public Lands Day	**19** *262*	**20** *263* Pollution Prevention Week IMPROVE particle sampling day
21 *264*	**22** *265* Autumn begins	**23** *266* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**24** *267*	**25** *268*	**26** *269* IMPROVE particle sampling day	**27** *270*
28 *271*	**29** *272* IMPROVE particle sampling day	**30** *273* Change IMPROVE particle cartridges.				

Aug 2014

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Oct 2014

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

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Operator Involvement -- The Key to Network Success

Trends: LAC
(Light Absorbing Carbon)

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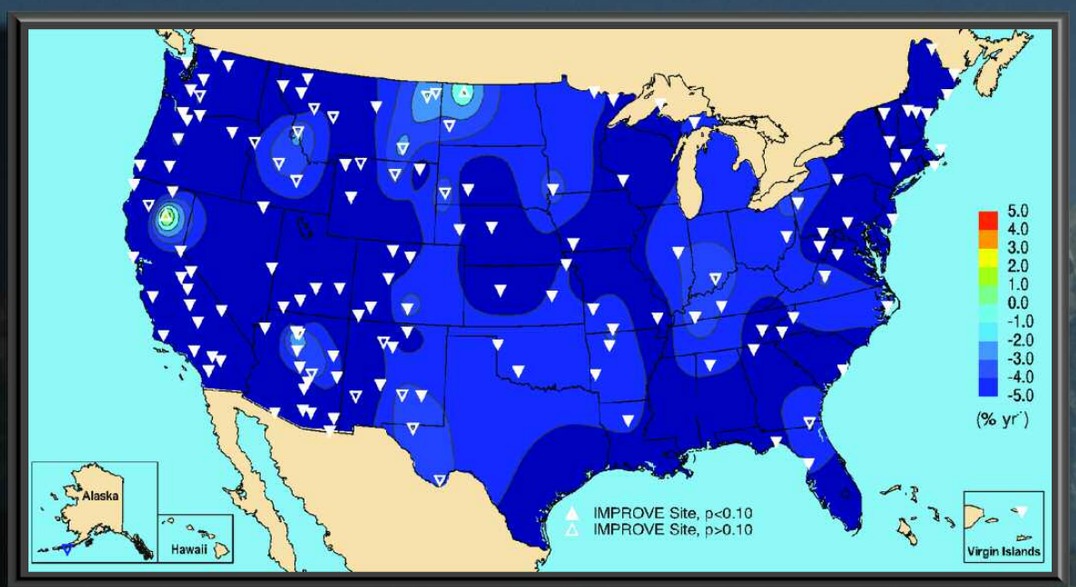

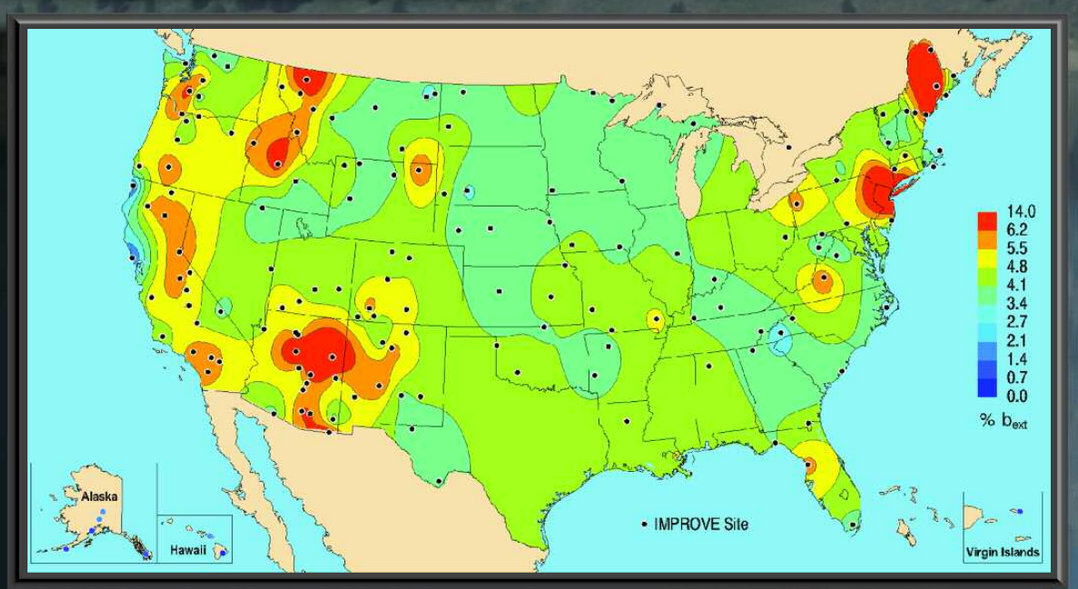

Trends over time of b_{ext} (visibility) are a result of changes over time of those particle species that contribute to b_{ext}. The first graph shows trends in light absorbing carbon (LAC) mass as a percent change in mass per year from 2000 to 2012 while the second graph shows the fraction of total extinction that can be attributed to LAC.

October

Wilderness is not a luxury but a necessity of the human spirit,
as vital to our lives as water and good bread.
– Edward Abbey

Sep 2014

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Nov 2014

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 *274 Julian day*	**2** *275* IMPROVE particle sampling day	**3** *276*	**4** *277*
5 *278* IMPROVE particle sampling day	**6** *279*	**7** *280* Change IMPROVE particle cartridges.	**8** *281* IMPROVE particle sampling day	**9** *282*	**10** *283*	**11** *284* IMPROVE particle sampling day
12 *285*	**13** *286* Columbus Day (Observed)	**14** *287* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**15** *288*	**16** *289*	**17** *290* IMPROVE particle sampling day	**18** *291*
19 *292*	**20** *293* IMPROVE particle sampling day	**21** *294* Change IMPROVE particle cartridges.	**22** *295*	**23** *296* IMPROVE particle sampling day	**24** *297*	**25** *298*
26 *299* IMPROVE particle sampling day	**27** *300*	**28** *301* Change IMPROVE particle cartridges.	**29** *302* IMPROVE particle sampling day	**30** *303*	**31** *304* Halloween	**UC Davis**: *Sampler*: General Lab (530) 752-1123 **ARS**: *Optical*: Carter Blandford or Karen Rosener *Photography*: Karen Fischer (970) 484-7941

Operator Involvement -- The Key to Network Success

Trends: Soil Dust

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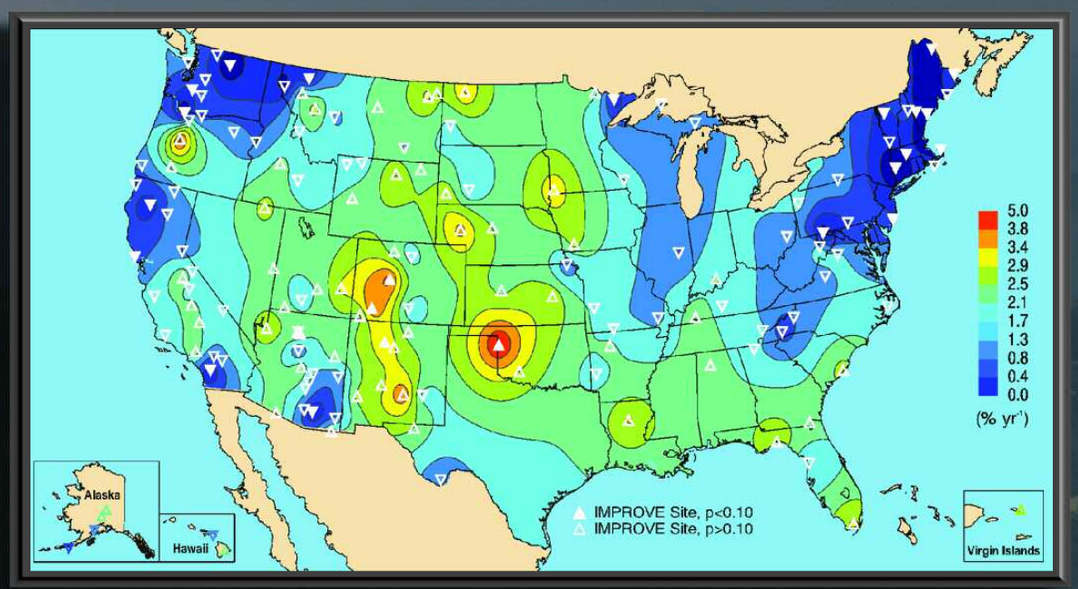

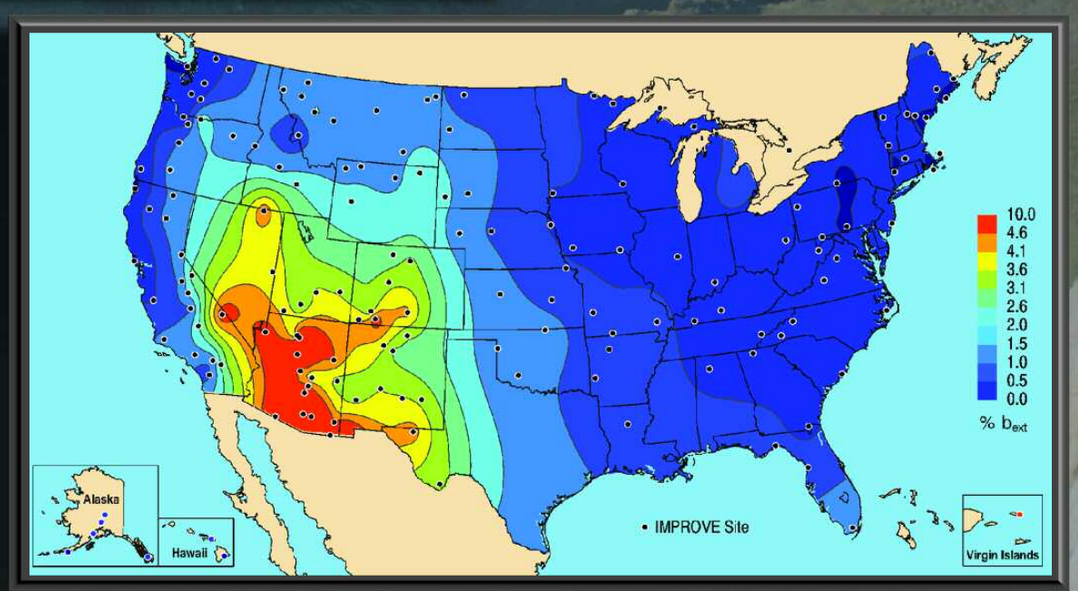

Trends over time of b_{ext} (visibility) are a result of changes over time of those particle species that contribute to b_{ext}. The first graph shows trends in soil dust mass as a percent change in mass per year from 2000 to 2012 while the second graph shows the fraction of total extinction that can be attributed to fine dust.

November

There is hope if people will begin to awaken that spiritual part of them, that heartfelt knowledge that we are caretakers of this planet.
– Brooke Medicine Eagle

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
◆ Electrical connections (e.g., extension cords) exposed to wet conditions should be GFCI protected. ◆ Watch for frost on the inlets.		Oct 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Dec 2014 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31			**1** *305 Julian day* IMPROVE particle sampling day
2 *306* Daylight Savings Time ends	**3** *307*	**4** *308* Election Day IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**5** *309*	**6** *310*	**7** *311* IMPROVE particle sampling day	**8** *312*
9 *313*	**10** *314* IMPROVE particle sampling day	**11** *315* Veterans Day Change IMPROVE particle cartridges.	**12** *316*	**13** *317* IMPROVE particle sampling day	**14** *318*	**15** *319* America Recycles Day
16 *320* National Park Service established, 1916 IMPROVE particle sampling day	**17** *321*	**18** *322* Change IMPROVE particle cartridges.	**19** *323* IMPROVE particle sampling day	**20** *324*	**21** *325*	**22** *326* IMPROVE particle sampling day
23 *327*	**24** *328*	**25** *329* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**26** *330*	**27** *331* Thanksgiving	**28** *332* IMPROVE particle sampling day	**29** *333*
30 *334*						

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Photography:
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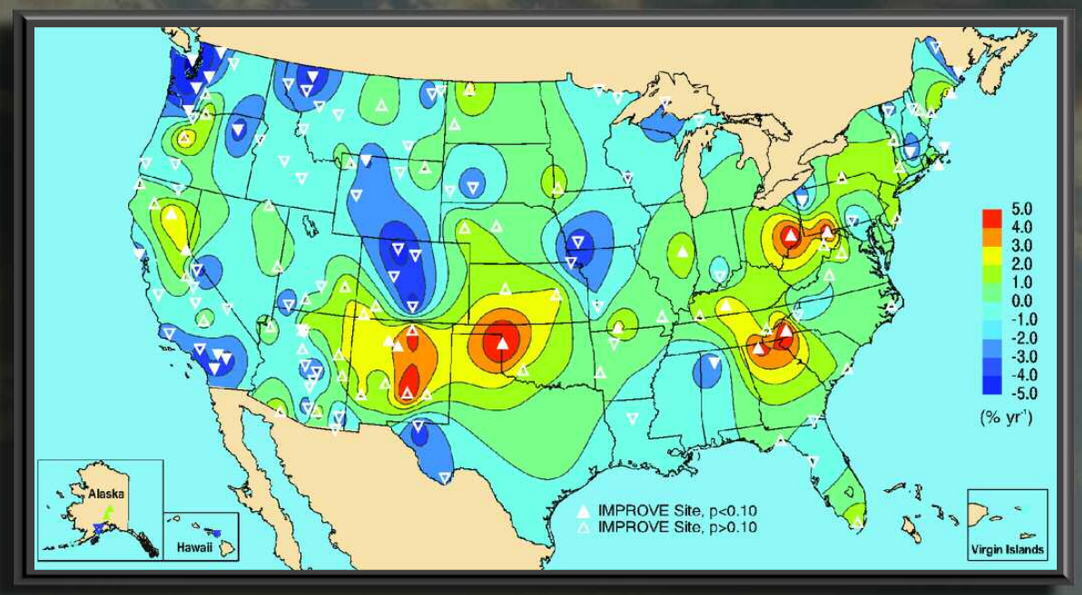
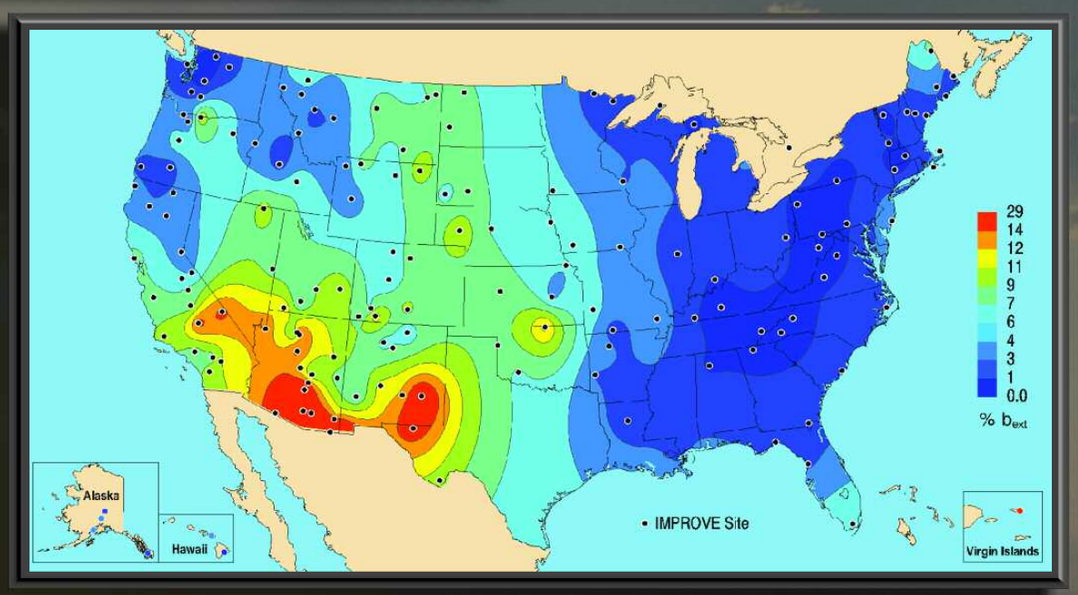
Operator Involvement -- The Key to Network Success

Trends: Coarse Mass

IMPROVE
Interagency Monitoring of Protected Visual Environments





Trends over time of b_{ext} (visibility) are a result of changes over time of those particle species that contribute to b_{ext}. The first graph shows trends in coarse mass as a percent change in mass per year from 2000 to 2012 while the second graph shows the fraction of total extinction that can be attributed to coarse mass.

December

Away, away, from men and towns, to the wild wood and the downs --
to the silent wilderness where the soul need not repress its music.
– Percy Bysshe Shelley

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
UC Davis: *Sampler*: General Lab (530) 752-1123 **ARS**: *Optical*: Carter Blandford or Karen Rosener *Photography*: Karen Fischer (970) 484-7941	**1** *335 Julian day* IMPROVE particle sampling day	**2** *336* Change IMPROVE particle cartridges.	**3** *337*	**4** *338* IMPROVE particle sampling day	**5** *339*	**6** *340*
7 *341* IMPROVE particle sampling day	**8** *342*	**9** *343* Change IMPROVE particle cartridges.	**10** *344* IMPROVE particle sampling day	**11** *345*	**12** *346*	**13** *347* IMPROVE particle sampling day
14 *348*	**15** *349*	**16** *350* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**17** *351*	**18** *352*	**19** *353* IMPROVE particle sampling day	**20** *354*
21 *355* Winter begins	**22** *356* IMPROVE particle sampling day	**23** *357* Change IMPROVE particle cartridges.	**24** *358*	**25** *359* Christmas IMPROVE particle sampling day	**26** *360*	**27** *361*
28 *362* IMPROVE particle sampling day	**29** *363*	**30** *364* Change IMPROVE particle cartridges.	**31** *365* New Year's Eve IMPROVE particle sampling day			

Nov 2014

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Jan 2015

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Operator Involvement -- The Key to Network Success

Operator Support

IMPROVE
Interagency Monitoring of Protected Visual Environments

Air Resource Specialists, Inc. (ARS) supports visibility monitoring networks for federal land management agencies, state agencies, municipalities, Indian nations, and private industry. ARS currently supports over 100 visibility monitoring sites nationwide and is the prime contractor for the IMPROVE program and the National Park Service and Forest Service visibility monitoring and data analysis programs.

ARS strongly encourages operators to call if there are any questions about parts, supplies, or instrument operations. It may be wise to call for instructions and troubleshooting advice before attempting to solve any problems. For questions or problems with IMPROVE sites, call 800-344-5423. For issues concerning special studies or non-IMPROVE sites, call 970-484-7941.

***Carter Blandford**, senior data analyst, performs data collection and validation and provides operator support for transmissometers and nephelometers.*

***Karen Rosener**, data analyst, performs data collection and validation and provides operator support for transmissometers and nephelometers.*

***Karen Fischer**, photographic specialist, performs image collection and system troubleshooting and provides operator support for photographic systems.*

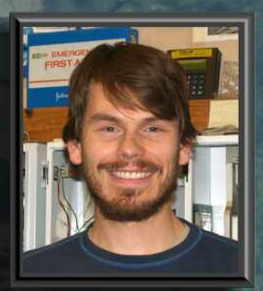
***Marty Mills**, electronics technician, performs servicing of transmissometers and nephelometers and troubleshooting of power-related instrument problems.*

The University of California, Davis, laboratory supports over 150 monitoring sites nationwide, including processing over 5,000 filters each month. Handling large volumes of filters and associated data requires carefully designed operating procedures that minimize errors between site operators and laboratory collection and analysis. As with any well-crafted plan, things can go wrong. Good communication between site operators and laboratory personnel, coupled with an awareness of potential problems, can improve overall data quality, decrease data loss, and aid in timely troubleshooting of field operations.

Three people in the lab are responsible for receiving the samples, preparing them for analysis, and preparing new samples for deployment. More importantly, they are great at helping operators figure out the content of each filter box if ever there is a filter mix-up. They can also track shipments for operators in case their boxes are late and schedule UPS pickups for operators who do not get visited by UPS on a daily basis. In short, for anything dealing with the actual filter boxes, these are the people to call.

***Tetsuya Anthony Kawamoto**,*
Sample Lab Technician / Operator Support
530-754-8770

Michael Truong,
Operator / Field Support
530-752-0933



Reuben Krofft,
Operator / Field Support
530-752-3440

Jose Mojica,
Field Supervisor / Operator / Data / Field Support
530-752-9044

January 2015

Not all is doom and gloom. We are beginning to understand the natural world and are gaining a reverence for life - all life.
– Roger Tory Peterson

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
UC Davis: *Sampler*: General Lab (530) 752-1123 **ARS**: *Optical*: Carter Blandford or Karen Rosener *Photography*: Karen Fischer (970) 484-7941				**1** *1 Julian day* New Year's Day	**2** *2*	**3** *3* IMPROVE particle sampling day
4 *4*	**5** *5*	**6** *6* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**7** *7*	**8** *8*	**9** *9* IMPROVE particle sampling day	**10** *10*
11 *11*	**12** *12* IMPROVE particle sampling day	**13** *13* Change IMPROVE particle cartridges.	**14** *14*	**15** *15* IMPROVE particle sampling day	**16** *16*	**17** *17*
18 *18* IMPROVE particle sampling day	**19** *19* Martin Luther King, Jr. Day	**20** *20*	**21** *21* IMPROVE particle sampling day	**22** *22*	**23** *23*	**24** *24* IMPROVE particle sampling day
25 *25*	**26** *26*	**27** *27* IMPROVE particle sampling day Special cartridge change: move cassette 3 from old cartridge to new.	**28** *28*	**29** *29*	**30** *30* IMPROVE particle sampling day	**31** *31*

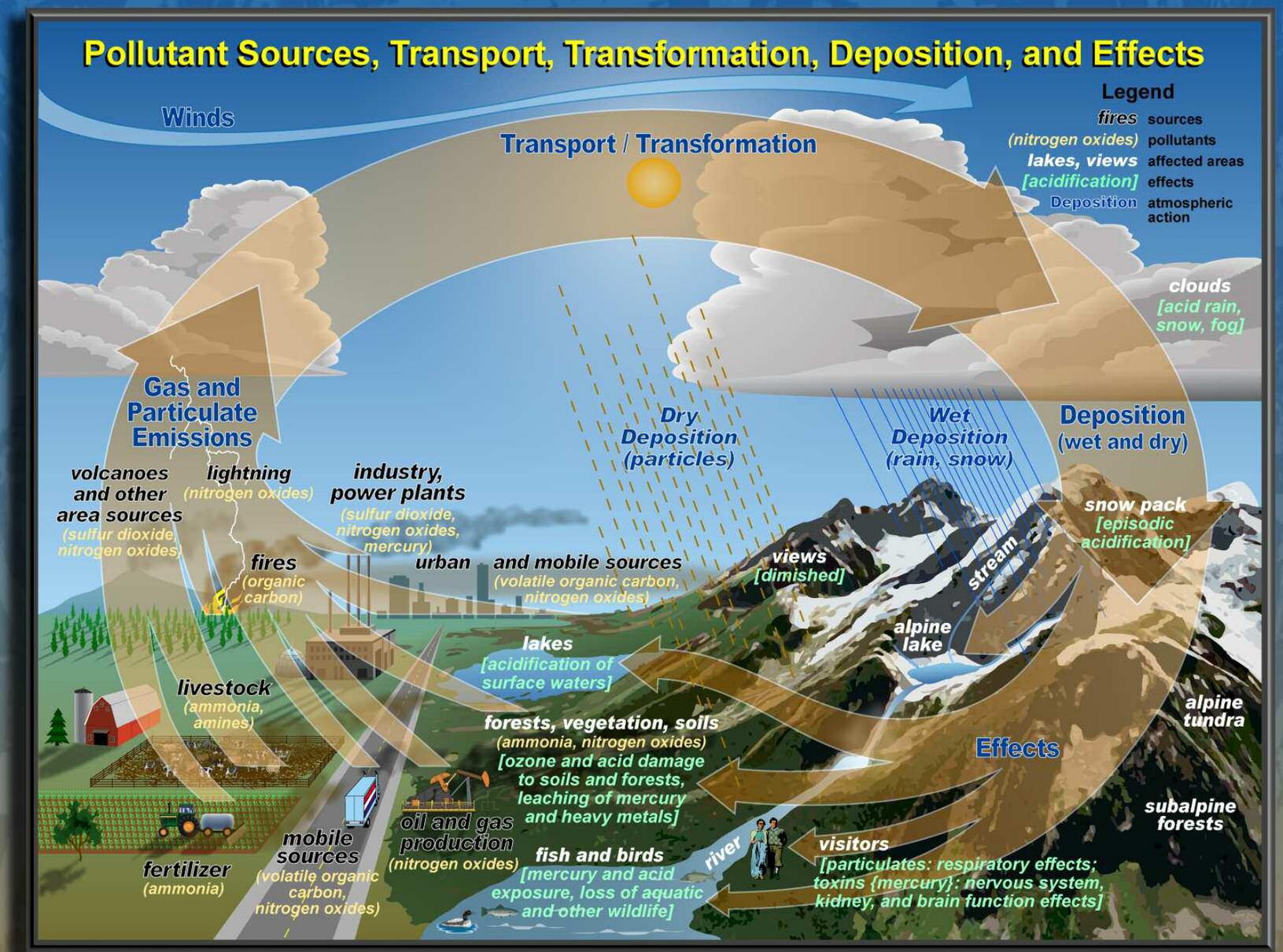
Dec 2014

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Feb 2015

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

Operator Involvement -- The Key to Network Success



Pollutant Sources, Transport, Transformation, Deposition, and Effects

This illustration shows the basic air pollution source types emitting various pollutants into the atmosphere where they are transported by winds, transformed into secondary pollutants, and deposited to the earth in dry particles or precipitation. Also shown are the various kinds of terrain affected, and the types of effects.

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For questions or problems with optical or scene monitoring equipment, contact Mark Tigges, Air Resource Specialists, Ft. Collins, CO, at 970-224-9300. For questions or problems with air sampler controllers, filters, or audits, contact Jose Mojica, UC Davis, at 530-752-1123.

Front cover photo: Near the Summit of Mt. Evans, Colorado, looking south. Photographer: Jeff Lemke
Calendar assembled and published by Jeff Lemke.