INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

2nd Quarter 2007 | The IMPROVE Newsletter | Volume 16 / Number 2

Feature Article:
The RoMANS Study of 2006, Page 4

Monitoring update

Network operation status

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

- 58 aerosol samplers
- 6 transmissometers
- 34 nephelometers
- 8 digital or film camera systems
- 57 Webcamera systems
- 5 interpretive displays

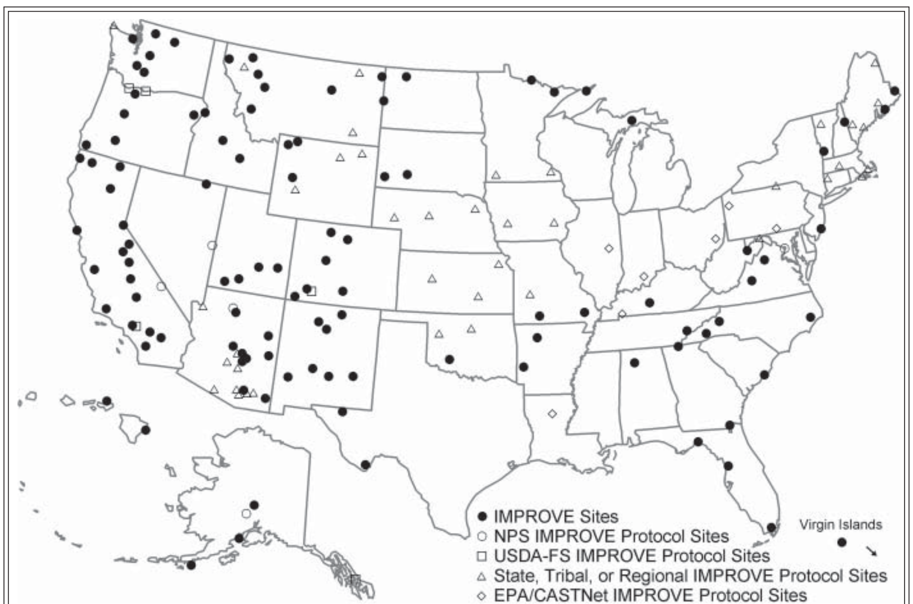
IMPROVE Program participants are listed on page 8. Federal land management agencies, states, tribes, regional air partnerships, and other agencies operate supporting instrumentation at monitoring sites as presented in the map below. Preliminary data collection statistics for the 2nd Quarter 2007 (April, May, and June) are:

- Aerosol (channel A only) — 95% collection
- Aerosol (all modules) — 93% completeness
- Optical (transmissometer) — 96% collection
- Optical (nephelometer) — 95% collection
- Scene (photographic) (does not include Webcameras) — 64% collection

The USDA-Forest Service sponsored camera system at Agua Tibia Wilderness (North), California, failed early in the quarter and was removed. Newer types of digital camera systems are being evaluated for possible replacement at the site.

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 July 2006. Transmissometer and nephelometer data are available through December 2006 and March 2007 respectively.



IMPROVE and IMPROVE Protocol Sites
2nd Quarter 2007

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

- National Park Service
  http://www2.nature.nps.gov/air/WebCams/index.htm
- USDA-Forest Service
  http://www.fsvisimages.com
- CAMNET (Northeast Camera Network)
  http://www.hazecam.net
- Midwest Haze Camera Network
  http://www.mwhazecam.net
- Wyoming Visibility Network
  http://www.wyvisnet.com
- Phoenix, AZ, Visibility Network
  http://www.phoenixvis.net

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

Visibility news

WRAP sponsors TSS workshop in Denver

The Western Regional Air Partnership (WRAP) Technical Oversight Committee sponsored a Technical Support System (TSS) workshop in June, which brought together over 50 air quality managers from across the western states. Workshop attendees learned about the various functions of the TSS during the two-day workshop.

The TSS is a Web-based resource inspired by WRAP and developed to aid air quality managers and planners in developing their haze plans. TSS users can access regional haze technical data, and display these data in various graphical elements through user-specified inputs. The TSS also facilitates ongoing tracking and assessment of emissions reductions. The resulting information is a valuable resource in supporting regional haze plans and the technical methodologies used in them.

TSS users may customize their results in graphs, tables, and maps, using the database's interactive queries. Workshop attendees learned what tools are available in the TSS, how to use them, and what results they will provide as well as display options.

The workshop provided plenary overview sessions interspersed with smaller training sessions for three TSS modules, which also allowed individuals the opportunity to ask specific questions. The three training session modules covered were:

- Haze planning/reasonable progress
- Technical results - emissions/visibility projections/ source apportionment
- Fire emissions tracking system

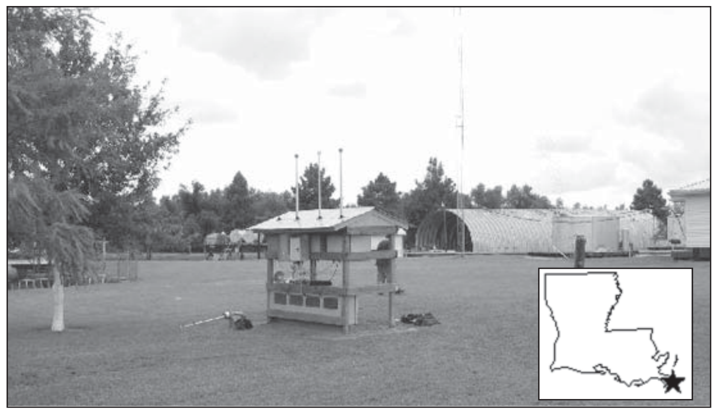
The TSS is continuing to develop into a comprehensive data tool integral to air managers and the development of their state implementation plans for regional haze. WRAP hopes to expand upon the tools of the TSS and its user base. The TSS home page can be found at *http://vista.cira.colostate.edu/tss/*.

For more information contact Tom Moore of WRAP. Telephone: 970/491-8837. E-mail: MooreT@cira.colostate.edu.

Search for new coastal LA site underway

Hurricane Katrina was one of the worst natural disasters ever to hit the United States. When the hurricane struck the Gulf Coast in late Summer 2005, all of south Louisiana felt its effects. Among the casualties was the Breton Island IMPROVE site, located in the Mississippi River Delta just a few miles upstream of the Gulf of Mexico. The entire sampling site was destroyed and the sampler was never recovered.

The sampler could not be replaced immediately due to the devastation in the region. Roads and electrical power were gone, and the first priority of government agencies was to restore basic services for the displaced population.



Former Breton National Wildlife Refuge, LA, IMPROVE station.

The rebuilding effort in the Gulf Coast is well underway, and IMPROVE is in the process of identifying a new location for the Breton site, with the goal of getting the sampler in place and operating by the end of 2007. The new location is likely to be east of New Orleans, and hence north of the old site, but still near the coastline. The new site will be on the mainland, an advantage that should alleviate the inconvenience of servicing the old site, which was accessible only by boat.

Further details will be provided in a subsequent edition of the IMPROVE Newsletter, once the new location has been established.

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

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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.*

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New IMPROVE site in New Hampshire

IMPROVE aerosol measurements are to begin later this year at Pack Monadnock Summit, near Peterborough, NH. IMPROVE sampling is being established at this site at the initiative of the U.S. EPA, the state of New Hampshire, and the University of New Hampshire. This new site will be assigned the IMPROVE site designation PACK1.

A state/university air monitoring station already exists at Pack Monadnock Summit, so the IMPROVE sampler will supplement existing measurements. Space and electrical power are in place, which will streamline the installation of the IMPROVE sampler. The sampler will be placed inside the shelter to provide protection from the sometimes severe winter weather.

Pack Monadnock Summit (elevation approximately 2,300 feet) is in southern New Hampshire and will be the highest in elevation IMPROVE site in the Northeast. This site will complement the existing IMPROVE site at Great Gulf Wilderness in northern New Hampshire. Other nearby IMPROVE sites are Lye Brook Wilderness and Proctor Maple Research Forest in Vermont; Quabbin Reservoir, Massachusetts; and Bridgton, Maine.

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The state/university air monitoring station on Pack Monadnock Summit, NH, will receive an IMPROVE sampler later this year.

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

Operators of distinction

Cedar Bluff State Park, KS, is just 850 acres, but it plays an important role in air quality monitoring. It is one of only three visibility monitoring sites in the state, so this IMPROVE Protocol site, operated by the state of Kansas, is important to not only the state but also to regional and federal programs.

Park Manager and IMPROVE site operator Chris Smith sees to it that quality monitoring is performed at Cedar Bluff, and the result is nearly 100% data are collected each quarter. The park's staff of four full-time employees spend most of their summers upgrading park facilities and maintaining its recreational offerings, but Park Ranger Steve Seibel and Maintenance Technician Mark Flax also help service the IMPROVE sampler. The park's air quality station also includes a nephelometer and meteorological sensors operated by the Kansas Department of Health and Environment and funded by the Central Regional Air Planning Association (CENRAP).

Chris previously worked as a Cedar Bluff State Park Ranger for nine years and as the current Cedar Bluff State Park Manager for two years, is responsible for its resources and recreation activities, including campsite and shoreline maintenance, cabin renovation, and boat ramp improvements. "We are also currently developing an interpretive nature trail in the park," said Chris. "All of us here at Cedar Bluff enjoy our jobs as public servants, and we want our visitors have an enjoyable and safe recreational experience." The park receives over a quarter million visitors annually.

According to the park's brochure, "They don't call it Cedar Bluff for nothing." The park has stunning views of the area, atop cedar covered limestone bluffs. "Good visibility and air quality are important resources for our visitors to enjoy what we offer here at Cedar Bluff," said Chris.

Chris has a B.S. degree in agriculture with an area of interest in park resource management from Kansas State University. Now with a wife and 8-year old son, he enjoys a variety of outdoor sports including hunting and fishing, as well as coaching youth sports.

Park Manager Chris Smith, Maintenance Technician Mark Flax, and Park Ranger Steve Seibel share the responsibility of servicing the air quality station at Cedar Bluff State Park, KS.

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

Feature article

The Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) Study of 2006

(by C.M. Carrico[1], S.M. Kreidenweis[1], J.L. Collett[1], T. Lee[1], A.P. Sullivan[1], G.R. McMeeking[1], S. Raja[1], F.M. Schwandner[1], K.L. Beem[1], C.A. Taylor[1], D.E. Day[2], J. Hand[2], M.A. Rodriguez[2], M.G. Barna[2], K.A. Gebhart[2], B.A. Schichtel[2], W.C. Malm[2]) [[1]Atmospheric Science Department, Colorado State University, Fort Collins, CO [2]U.S. National Park Service/Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, CO]

Introduction

Long-term air quality monitoring at Rocky Mountain National Park (RMNP) shows increasing atmospheric deposition of key nitrogen-containing species[1,2], and the nitrogen deposition may be exceeding the "critical load," resulting in ecosystem damage[3]. Excess nitrogen is particularly disruptive to alpine ecosystems that historically have been nitrogen limited[1,4]. Nitrogen deposition effects range from aquatic chemistry changes (e.g., nitrate enhancement in runoff) to increasing prevalence of nitrophilic plant species (e.g., deciduous rather than coniferous trees, grasses, and sedges rather than wildflowers)[5].

Atmospheric nitrogen compounds have many sources including industrial, transportation, agricultural, livestock, forest fires, and natural sources. They may be emitted directly (primary source) formed in the atmosphere from precursors (secondary source), existing in the gas, particle, and aqueous phases. They are deposited from the atmosphere to surfaces in the park via dry and wet deposition processes, the latter including rain- and snowfall.

Routine monitoring in RMNP including IMPROVE has provided invaluable information on important nitrogen compounds. However, potentially important compounds such as ammonia (NH_3) and organic nitrogen (ON) species have not been routinely measured, and sources are not well understood.

RoMANS objectives

In response, the U.S. National Park Service and the state of Colorado sponsored the Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) Study. As part of RoMANS, two 5-week intensive measurement campaigns occurred during the historical peaks in the atmospheric concentrations and deposition fluxes of nitrogen and sulfur species, namely in early spring (23 March - 30 April 2006) and mid-summer (5 July - 12 August 2006). RoMANS employed a network of sampling sites located throughout Colorado and a more heavily instrumented core site, collocated with the long-term IMPROVE and CASTNET sampling sites in the park. Specific objectives of the RoMANS study included:

- Identify the overall mix of sulfur and oxidized and reduced nitrogen in the air and precipitation, on both the east and west sides of the Continental Divide.
- Identify the relative contribution to atmospheric oxidized sulfur and oxidized and reduced nitrogen at RMNP from emissions originating within the state of Colorado vs. outside the state.
- Identify the relative contribution to atmospheric oxidized sulfur and oxidized and reduced nitrogen at RMNP from emissions originating along the Front Range vs. other regions within the state.
- Identify the relative contribution of various source types within the state of Colorado to nitrogen and sulfur species, including mobile, agricultural, other area's sources, and large and small point sources.
- Map spatial and temporal variability of atmospheric deposition within the park and relate observed patterns to likely source types and locations.
- Characterize the meteorological conditions that lead to various atmospheric chemical conditions.

Experimental methods

At the RoMANS core site, particulate-phase $PM_{2.5}$ concentrations of major ions including ammonium (NH_4^+) and nitrate (NO_3^-) were measured with a high time resolution Particle Into Liquid Sampler (PILS). IMPROVE network samplers provided 24-hour average concentrations of the same and a range of other species for comparison. Analytical techniques included ion chromatographic analysis of particulate and precipitation samples. Gas species, including nitrogen oxides (NO_2, NO), nitric acid (HNO_3) and ammonia (NH_3) were measured with commercial, trace-level gas analyzers and gas denuders. Precipitation samples were collected and analyzed for major ions and total ON.

Meteorological parameters were measured with standard surface stations as well as an upper air wind profiler located near RMNP. Meteorological data from EDAS (40 km horizontal resolution) and MM5 (nested grids of 4, 12, and 36 km) meteorological models are used in exploring atmospheric transport during the study.

Results and discussion

Particulate nitrogen concentrations fluctuated but remained relatively low during 16-20 April (Figure 1) and the preceding week.

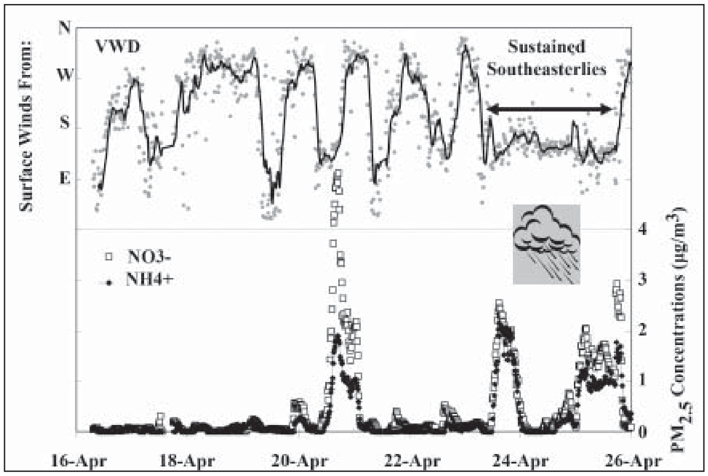

Figure 1. Time history of vector wind direction (VWD) and particulate-phase nitrogen species concentrations from 16-26 April 2006 at the core site in RMNP. A major precipitation event is indicated.

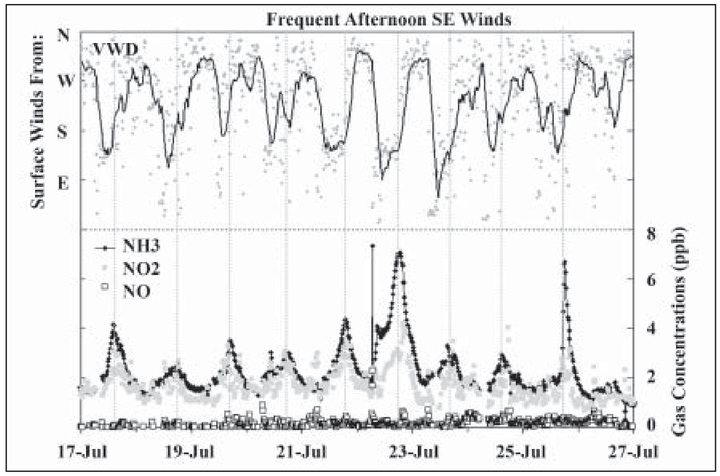

Figure 2. Time history of vector wind direction (VWD) and gas-phase nitrogen species concentrations from 17-27 July 2006 at the core site in RMNP. Daily peaks in NH_3 and NO_2 concentrations often follow changes to southeasterly winds as indicated.

Beginning around 20 April, higher concentration events were recorded for both particulate-phase species and gas concentrations, discussed later. Snowfall in April was dominated by a single synoptic-scale event associated with a cold frontal passage (ambient temperature dropped from 14.7°C at 10:00 to 4.3°C at 17:00 MST). A shift of surface winds at the core site to persistent southeasterlies accompanied the frontal passage (Figure 1). During the afternoon of 23 April, as winds shifted to southeast origins, particulate-phase nitrogen concentrations increased sharply.

Precipitation occurred from 21:00 on 23 April through 09:00 on 25 April (16.5 mm total), causing particle-phase concentrations of NO_3^- and NH_4^+ to drop. After the precipitation event, $PM_{2.5}$ concentrations of nitrogen species increased while southeasterly surface winds persisted (Figure 1). Nitrogen gases including NO, NO_2 and NH_3 are not shown here but exhibit similar periods of low and high concentrations during this period but less influence from the precipitation event.

During the summer campaign, a thermal mountain-valley wind pattern developed, with a corresponding diurnal pattern in atmospheric nitrogen concentrations, shown for gas species in Figure 2. These species often peaked during late afternoons in upslope flow conditions shown by southeasterly surface winds (Figure 2). Frequent, though scattered afternoon precipitation events were often associated with upslope flow.

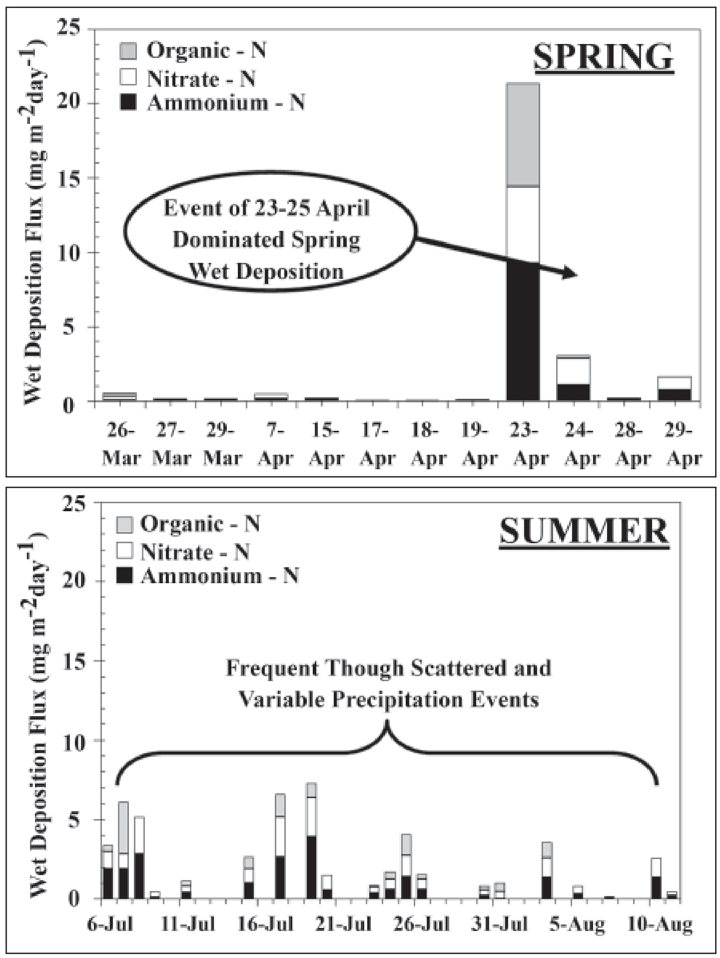

Figure 3. Timeline of wet deposition nitrogen fluxes based on 24-hour precipitation samples (08:00-08:00 MST) during the spring and summer RoMANS campaigns.

The nitrogen wet deposition event of 23-25 April dominated total deposited nitrogen at the core site during RoMANS (Figure 3). Contrastingly, deposition events were more frequent and uniformly distributed over the summer study period as shown in the second panel in Figure 3. Despite the large spring deposition event, total nitrogen deposition was approximately twice as large during the summer campaign than in the spring (Figure 3). Overall during both RoMANS campaigns, approximately two-thirds of the total nitrogen deposition at the core site was via wet deposition.

Speciation of precipitation samples showed varying contributions over time to the total wet-deposited nitrogen from NO_3^-, NH_4^+, and ON species dissolved in the precipitation (Figure 3). The contribution of organic nitrogen species is key (~ 30% of total wet deposited N and at times the majority), as ON is not routinely monitored which may lead to underestimates of total nitrogen deposition. NH_3 and HNO_3 were the largest quantified contributors to dry deposition, with an unknown though potentially important contribution from organic nitrogen.

Atmospheric transport and deposition modeling is challenging due to the complex terrain in the Rocky Mountains. As an example, the frequency of contact with model grid cells for the back trajectories of air masses arriving at RMNP on 24 April are computed using data from the Eta Data Assimilation Model (EDAS) and the Firth Generation Penn State/NCAR Mesoscale Model (MM5) (Figure 4). The latter provides much finer spatial resolution both horizontally and vertically, and also assimilates meteorological measurements from RoMANS sites. Both model runs predict similar transport pathways from the northeast immediately upwind of the site. Further back in time, however, transport pathways diverge, with EDAS data suggesting air mass origins in the Northwest U.S. and MM5 data indicating upper Midwest U.S. origins during this event. This underscores the importance of using the most detailed meteorological information available in ongoing modeling of the complex mountain transport and deposition.

Conclusions

Measurements during the RoMANS field study in 2006 yielded new insights into the dominant species and pathways for atmospheric nitrogen deposition in RMNP. Such observations provide guidance for ongoing measurements of nitrogen species in the IMPROVE and other monitoring networks. Wet deposition accounted for approximately two-thirds of total deposition at the study core site. Wet deposition during the spring campaign was dominated by a single synoptic scale event on 23-25 April. In contrast, more frequent, though lighter afternoon precipitation events occurred throughout the summer. In both seasons, these events were often associated with upslope flow conditions, as indicated by local surface-level winds from the east or southeast. Organic nitrogen (ON) species accounted for nearly one-third of the total wet-deposited nitrogen, and the majority during specific events, with ammonium and nitrate contributing the balance. Atmospheric ON concentrations are not routinely measured and thus their deposition contributions are not well quantified. A significant ON presence suggests that previous models based on inorganic fluxes alone significantly underestimate total nitrogen deposition. Transport and deposition modeling is an ongoing effort to better understand the major source types and regions that contribute most to the total annual nitrogen deposition in RMNP.

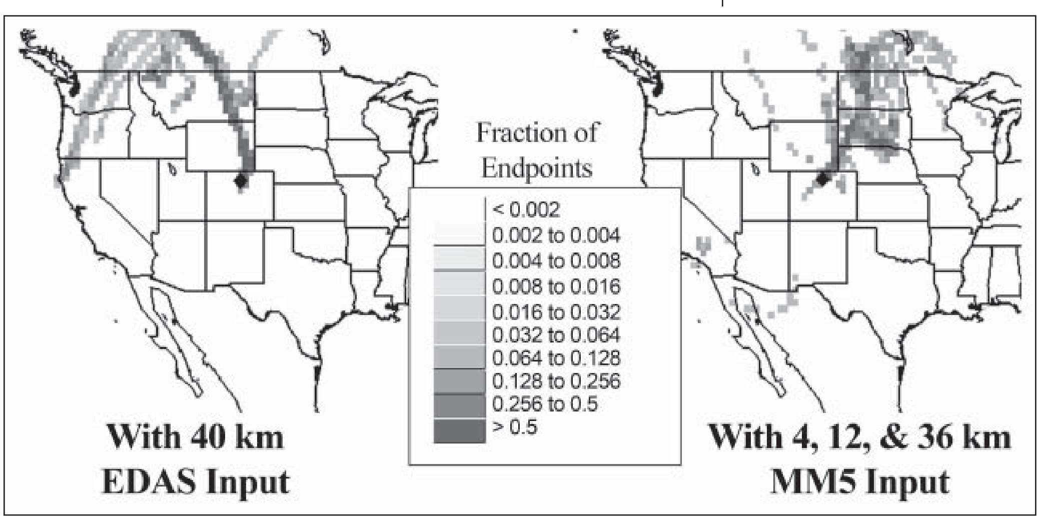

Figure 4. Frequency of contact with geographical grid cells using 5-day back trajectories for air masses arriving at the RoMANS core site for the 24-hour period on 24 April 2006. Back trajectories were calculated using the NOAA HYSPLIT model with 40 km horizontal resolution EDAS data (left) and with nested grid (4, 12, and 36 km) MM5 data (right).

Acknowledgements

We acknowledge Air Resource Specialists, Inc.; Judy Visty, Laura Wheatley, Lisa Foster, and the staff of Rocky Mountain National Park for their support; and the National Park Service and the state of Colorado for sponsorship.

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For more information contact Kip Carrico at Colorado State University. Telephone: 970/491-8667. E-mail: carrico@lamar.colostate.edu.

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

Outstanding sites

Data collection begins with those who operate, service, and maintain monitoring instrumentation. IMPROVE managers and contractors thank all site operators for their efforts in caring for IMPROVE and IMPROVE Protocol networks. Sites that achieved 100% data collection for 2nd Quarter 2007 are:

Aerosol (Channel A)

Addison Pinnacle	Ike's Backbone	Rocky Mountain
Arendtsville	Isle Royale	Sac and Fox
Badlands	Joshua Tree	Saguaro West
Bandelier	Kalmiopsis	San Gorgonio
Big Bend	Lassen Volcanic	San Pedro Parks
Birmingham	Lava Beds	San Rafael
Cabinet Mountains	Livonia	Sawtooth
Canyonlands	Lostwood	Seney
Capitol Reef	Mingo	Shenandoah
Chassahowitzka	M.K. Goddard	Sikes
Columbia Gorge East	Mohawk Mountain	Sipsey
Columbia Gorge West	Moosehorn	Snoqualmie Pass
Craters of the Moon	Mount Rainier	Theodore Roosevelt
Death Valley	New York	Three Sisters
Dolly Sods	North Cascades	Trapper Creek-Denali
Fresno	Olympic	Trinity
Frostburg Reservoir	Omaha	Upper Buffalo
Grand Canyon	Penobscot	Viking Lake
Great River Bluffs	Phoenix	Weminuche
Haleakala	Pinnacles	White River
Hawaii Volcanoes	Point Reyes	Wind Cave
Hercules-Glades	Proctor Research Center	Yosemite
Hoover	Quabbin Reservoir	

Transmissometer

Grand Canyon (In Canyon)   Thunder Basin

Nephelometer

Chiricahua	Mount Rainier	Phoenix
Great Smoky Mountains	National Capital	Queen Valley
Ike's Backbone	Petrified Forest	Shenandoah

Photographic

Agua Tibia   Gates of the Mountains   Grand Canyon

Monitoring Site Assistance:
Aerosol sites: contact University of California-Davis telephone: 530/752-7119 (Pacific time)
Optical/Scene sites: contact Air Resource Specialists, Inc. telephone: 970/484-7941 (Mountain time)

Sites that achieved at least 95% data collection for 2nd Quarter 2007 are:

Aerosol (Channel A)

Acadia	Meadview	San Gabriel
Bliss	Medicine Lake	Sequoia
Bryce Canyon	Mount Baldy	Shamrock Mine
Cape Romain	Mount Hood	Shining Rock
Cherokee	Mount Zirkel	Swanquarter
Crescent Lake	Nebraska	Sycamore Canyon
Egbert	North Absaroka	Tallgrass
Everglades	Organ Pipe	Washington DC
Fort Peck	Petersburg	Wheeler Peak
Great Sand Dunes	Presque Isle	White Pass
Great Smoky Mtns.	Puget Sound	Wichita Mountain
James River	Quaker City	Yellowstone
Makah	Queen Valley	

Transmissometer

Bridger   Grand Canyon (S Rim)   San Gorgonio

Nephelometer

Big Bend	Grand Canyon (Indian Gardens)	Sierra Ancha
Children's Park	Greer	Sycamore Canyon
Craycroft	Mammoth Cave	Thunder Basin
Dysart	Mount Zirkel	Tucson Central
Estrella	Organ Pipe	Tucson Mountain
Grand Canyon (Hance)		Vehicle Emissions

Photographic

-- none --

Sites that achieved at least 90% data collection for 2nd Quarter 2007 are:

Aerosol (Channel A)

Bondville	Ellis	Northern Cheyenne
Boundary Waters	Flathead	Pasayten
Bridger	Gates of the Mountains	Petrified Forest
Brigantine	Glacier	Salt Creek
Caney Creek	Guadalupe Mountains	Simeonof
Casco Bay	Haleakala Crater	Starkey
Cedar Bluff	Indian Gardens	Thunder Basin
Cloud Peak	Jarbidge	U.L. Bend
Crater Lake	Kaiser	Virgin Islands
Denali	Linville Gorge	Voyageurs
Douglas	Martha's Vineyard	White Mountain
El Dorado Springs	Mesa Verde	Zion Canyon

Transmissometer

--none--

Nephelometer

Acadia   Cloud Peak

Photographic

--none--

IMPROVE

The IMPROVE Newsletter

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

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