



NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

NADP 2007
Wet & Dry Deposition Measurements:
Do We Have the Total Picture?

10 – 13 September 2007 · Boulder, Colorado

The National Atmospheric Deposition Program (NADP) provides quality-assured data and information in support of research on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, mercury, and base cations in precipitation. These data support informed decisions on air quality issues. The NADP seeks to respond to emerging issues and continues to evaluate changes in its measurement systems, including the addition of other chemical and biological species. In 2006, scientists, educators, students, and others interested in the NADP logged nearly 350,000 sessions on the NADP Web site and viewed more than 121,000 concentration and deposition maps, an increase of 30 percent from 2005. Users downloaded 23,664 data files from this site, which now annually receives more than 1.4 million hits.

The NADP was organized in 1977 under State Agricultural Experiment Station (SAES) leadership to address the problem of atmospheric deposition and its effects on agricultural crops, forests, rangelands, surface waters, and other natural and cultural resources. In 1978, sites in the NADP precipitation chemistry network first began collecting one-week, wet-only deposition samples analyzed by the Central Analytical Laboratory (CAL) at the Illinois State Water Survey. The network was established to provide data on amounts, temporal trends, and geographic distributions of the atmospheric deposition of acids, nutrients, and base cations by precipitation. The NADP initially was organized as SAES North Central Regional Project NC-141, which all four SAES regions endorsed as Interregional Project IR-7 in 1982. A decade later, IR-7 was reclassified as National Research Support Project NRSP-3, which it remains.

In October 1981, the federally supported National Acid Precipitation Assessment Program (NAPAP) was established to increase understanding of the causes and effects of acidic precipitation. This program sought to establish a long-term precipitation chemistry network of sampling sites distant from point source influences. Because of its experience in organizing and operating a national-scale network, the NADP agreed to coordinate operation of NAPAP's National Trends Network (NTN). To benefit from identical siting criteria and operating procedures and a shared analytical laboratory, NADP and NTN merged with the designation NADP/NTN. Many NADP/NTN sites were supported by the U.S. Geological Survey, NAPAP's lead federal agency for deposition monitoring. Under Title IX of the federal Clean Air Act Amendments of 1990, NAPAP continues. Today there are more than 250 sites in the network, and the network designation has been shortened to NTN.

In October 1992, the Atmospheric Integrated Research Monitoring Network (AIRMoN), currently with seven sites, joined the NADP. AIRMoN sites collect samples daily when precipitation occurs. Samples are refrigerated until analysis at the CAL for the same constituents measured in NTN samples. The AIRMoN seeks to investigate pollutant source/receptor relationships and the effect of emissions changes on precipitation chemistry, combining measurements with atmospheric models. The AIRMoN also evaluates sample collection and preservation methods.

In January 1996, the Mercury Deposition Network (MDN), currently with more than 100 sites, joined the NADP. MDN sites collect wet-only deposition samples that are sent to the MDN analytical laboratory at Frontier Geosciences, Inc. The MDN was formed to provide data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors. Forty-eight states and eight Canadian provinces have advisories against consuming fish from lakes with high mercury concentrations in fish tissues. MDN data enable researchers to investigate the link between mercury in precipitation and this problem.

The NADP receives support from the U.S. Geological Survey; Environmental Protection Agency; National Park Service; National Oceanic and Atmospheric Administration; U.S. Department of Agriculture - Forest Service; U.S. Fish & Wildlife Service; Tennessee Valley Authority; Bureau of Land Management; and U.S. Department of Agriculture - Cooperative State Research, Education, and Extension Service under agreement 2007-39138-18202. Additional support is provided by other federal, state, local, and tribal agencies, State Agricultural Experiment Stations, universities, and nongovernmental organizations. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture or any other sponsor.

For further information, contact:

**NADP Program Office
Illinois State Water Survey
2204 Griffith Drive
Champaign, IL 61820**

NADP Home Page: <http://nadp.sws.uiuc.edu>
E-mail: nadp@sws.uiuc.edu
Phone: 217/333-7871
Fax: 217/333-0249

**NADP 2007
Technical Committee Meeting**

September 10 – 12, 2007
Boulder, Colorado

Technical Program Chair
Tom Butler
Cornell University

PROCEEDINGS

Prepared by

**Kathryn E. Douglas
Athena Newcomb
NADP Program Office
Illinois State Water Survey
2204 Griffith Drive
Champaign, IL 61820**

September 2007

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NADP Scientific Symposium Agenda

**NADP Technical Meeting and Scientific Symposium
Boulder, Colorado
September 10 – 12, 2007**

Monday, September 10, 2007		Room Location
Registration Desk Open All Day		Sunshine Room
8:00 a.m. to 10:00 a.m.	Joint Subcommittee Meetings	Canyon Half of Ballroom
10:00 a.m. to 10:20 a.m.	Break	
10:20 a.m. to 12:00 noon	Subcommittee Meetings Network Operations Data Management & Analysis Ecological Response and Outreach Critical Loads (ad hoc)	Canyon Half of Ballroom Suite 231 Suite 331 Suite 431
12:00 noon to 1:30 p.m.	Lunch (on your own)	
1:30 p.m. to 2:45 p.m.	Subcommittee Meetings	
2:45 p.m. to 3:00 p.m.	Break	Sunshine Room
3:00 p.m. to 5:00 p.m.	Executive Committee Meeting	Canyon Half of Ballroom
Tuesday, September 11, 2007		
Registration Desk Open All Day		Sunshine Room
8:00 a.m. to 9:30 a.m.	Program Office Report, Awards, and Announcements Van Bowersox, NADP Coordinator Maggie Kerchner, NOAA, NADP Chair	Canyon Half of Ballroom
Technical Session:	TOTAL NITROGEN DEPOSITION Session Chair: Rick Artz NOAA, Air Resources Lab	
9:30 – 9:45	Is There More to Total Deposition than Wet and Dry: Lessons from and Utility of Throughfall Kathleen Weathers, Institute of Ecosystem Studies	
9:45 - 10:00	Results of the Southern Ontario Ammonia Passive Sampler Survey (SOAPSS) Mike Shaw, Environment Canada	

Tuesday, September 11, 2007

Room Location

Technical Session:	TOTAL NITROGEN DEPOSITION (CONTINUED) Session Chair: Rick Artz NOAA, Air Resources Lab	Canyon Half of Ballroom
10:00 – 10:15	Model Estimated Components of Oxidized Nitrogen Dry Deposition Not Covered by the Networks, with a Focus on Urban Deposition Robin Dennis, NOAA, Air Resources Lab	
10:15 – 10:30	Modeling Nitrate Concentrations and Deposition: Sensitivities to Cloud Treatment and Land Use Alice Gilliland, ASMD, NOAA, ARL in partnership with NERL, U.S. EPA	
10:30 a.m. to 10:40 a.m.	Break	Sunshine Room
10:40 – 10:55	Nitrogen Isotopes in Dry Deposition: Can CASTNET and Passive Samplers Be Used to Partition Contributions of NO_x Sources? Emily Elliott, University of Pittsburgh	
10:55 – 11:10	Detecting Past and Future Trends in Nitrogen Deposition: A Modeling Study to Guide the Placement of Future Monitoring Sites Robert Pinder, ASMD, NOAA, ARL in partnership with NERL, USEPA	
11:10 – 11:25	Semiempirical Model Estimates of Ammonia Dry Deposition to North Carolina Coastal Watersheds John Walker, U.S. Environmental Protection Agency	
11:25 – 11:40	What Modifications in the National Deposition Monitoring Networks are Required to Be Able to Measure and Source Apportion Representations of all Reactive Nitrogen Species? William Malm, National Park Service, CIRA/CSU	
11:40 a.m. to 1:00 p.m.	Lunch (on your own)	

Tuesday, September 11, 2007

Room Location

Technical Session:	ECOLOGICAL IMPACTS OF ATMOSPHERIC DEPOSITION Session Chair: Pamela Padgett USDA Forest Service	Canyon Half of Ballroom
1:00 – 1:18	A Reversal of Acidification Recovery Trends in Stream-Water Chemistry in the Catskill Mountain Region of New York Doug Burns, U.S. Geological Survey, NAPAP	
1:18 – 1:35	Effects of Acid Rain on the Chemistry of Western Adirondack Streams in 2003-2005 Greg Lawrence, U.S. Geological Survey	
1:35 – 1:53	Regional Estimates of Contaminant Deposition in Aquatic Ecosystems Frank McCormick, USDA Forest Service	
1:53 – 2:05	Predicting Change in Nitrogen Loading to Escambia Bay Due to Additional Point Source Controls on a Nearby Power Plant Michele Cutrofello, RTI International	
2:05 – 2:23	Investigating the Effects of Nitric Acid on <i>Ramalina menziesii</i> Tayl Jennifer Riddell, Arizona State University School of Life Sciences	
2:23 – 2:45	Understanding the Interactive Effects of Nitrogen Deposition, Global Warming, and Increased Snowfall on the Encroachment of Woody Shrubs into the Alpine Tundra Isabel Ashton, University of California, Irvine	
2:45 p.m. to 3:00 p.m.	Break	Sunshine Room

Tuesday, September 11, 2007

Room Location

Technical Session:

**CLIMATE CHANGE/GREENHOUSE
GAS MITIGATION**

Session Chair: Angela Zahniser
Bureau of Land Management

Canyon Half of
Ballroom

3:00 – 3:20

Emerging Climate Change Science and Policy

Jason Samenow, U.S. EPA

3:20 – 3:40

**Our Changing Climate: The Underlying Role of
Biogeochemistry**

Elizabeth Holland, National Center for Atmospheric
Research

3:40 – 4:00

**Impacts of Climate Change and Global Emissions
on PM2.5 and Ozone Levels in the United States:
A Sensitivity Assessment and Development of an
Integrated Modeling Framework**

Peter Adams, Carnegie Mellon University

4:00 – 4:20

**Carbon Capture and Sequestration: Potential,
Challenges, and Outlook**

John Venezia, World Resources Institute

4:20 – 4:40

**Manure-DNDC: Building a Process Based
Biogeochemical Tool for Quantifying Ammonia
and GHG Emissions and Mitigation Opportunities
for California Dairies**

William Salas, Applied Geosolutions

4:40 – 5:00

**Impacts of Climate and Land Use Change on
Soil Trace Gas Fluxes**

Steve Del Grosso, USDA ARS NPA SPNR

5:00 – 5:20

**Land Use Carbon Mitigation Options in the
Northeastern U.S.**

Sarah Walker, Winrock International

5:30 p.m. to 8:00 p.m.

Poster Session and Outdoor BBQ

Century Room &
Pavilion

Wednesday, September 12, 2007

Room Location

Technical Session:

DEPOSITION EFFECTS IN ALPINE ENVIRONMENTS

Session Chair: Kristi Morris
National Park Service

Canyon Half of Ballroom

8:00 – 8:20

Observations of Airborne Pollutants and Deposition during the 2006 Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS) Study

Jeff Collett, Colorado State University

8:20 – 8:40

Simulating Deposition with a Regional Air Quality Model for the Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) Study

Michael Barna, National Park Service

8:40 – 9:00

Nitrogen Saturation in the Rocky Mountains: Linking Emissions, Deposition, and Ecosystem Effects Using Stable Isotopes of Nitrogen Compounds

Donald Campbell, U.S. Geological Survey

9:00 – 9:20

Spatial Distribution of Nitrogen Deposition in Rocky Mountain National Park, USA

David Clow, U.S. Geological Survey

9:20 – 9:40

What is Causing the Recent Increases in NO₃ in Loch Vale Surface Waters?

Jill Baron, U.S. Geological Survey, Natural Resource Ecology Lab, Colorado State University

9:40 – 10:00

N Deposition Effects on Vegetation and Soils in Alpine Ecosystems

William Bowman, University of Colorado - Boulder

10:00 – 10:10

Nitric Acid Dry Deposition at Conifer Forests: Niwot Ridge, Colorado, Subalpine Spruce-Fir Study

Herman Sievering, University of Colorado – Boulder, University of Colorado – Denver

10:10 a.m. to 10:30 a.m.

Break

Sunshine Room

Wednesday, September 12, 2007

Room Location

Technical Session:

CRITICAL LOADS
Session Chair: Ellen Porter
National Park Service

Canyon Half of
Ballroom

10:30 – 10:50 **Integrated Assessment Methods Used for
Optimized Air Pollution Mitigation in Europe**

Harald Sverdrup, Lund University, Sweden

10:50 – 11:10 **Recent Developments in Determining Critical
Loads for Sulphur and Nitrogen Deposition in
Western Canada**

Silvina Carou, Environment Canada

11:10 – 11:30 **Overview of Recent Critical Load Efforts in the U.S.**

Rick Haeuber, U.S. EPA

11:30 – 11:50 **A Multi-agency Critical Loads Development and
Implementation Process for the Northeast U.S.**

Gary Kleiman, NESCAUM/NESCCAF

11:50 – 12:10 **Integrating a Critical Load for Rocky Mountain
National Park into the State of Colorado's
Planning Process**

Mike Silverstein, Colorado Department of Public
Health and Environment

12:10 p.m. to 1:30 p.m.

Lunch (on your own)

Technical Session:

TOTAL MERCURY DEPOSITION
Session Chairs: Eric Prestbo, Tekran Corporation
David Gay, Illinois State Water Survey

1:30 – 2:00 **Mercury Dry Deposition almost Two Decades
Later: Musings of an O.F.**

Steve Lindberg, ERC (enjoying retirement completely)

2:00 – 2:20 **Wet and Dry Deposition of Atmospheric Hg at
Three Sites across the Southeastern U.S.**

Eric Edgerton, ARA, Inc.

Wednesday, September 12, 2007

Room Location

Technical Session:	TOTAL MERCURY DEPOSITION (CONTINUED) Session Chairs: Eric Prestbo Tekran Corporation David Gay Illinois State Water Survey	Canyon Half of Ballroom
2:20 – 2:40	Atmospheric Mercury Measurements in the Gulf of Mexico and Mid-Atlantic Regions: Early Results from an Emerging Monitoring Network Winston Luke, NOAA, Air Resources Lab	
2:40 – 3:00	Trends and Modeling of the Total Gaseous Mercury Flux and Mercury Deposition in the Leaf Litter Fall in a Northeastern Red Maple Canopy Jesse Bash, NOAA - Air Resources Lab, U.S. EPA – NERL	
3:00 – 3:20	Strategies to Assess Mercury Impacts and Minimize Their Effects in Colorado and Beyond Mark McMillan, Colorado Department of Health and Environment	
3:20 – 3:40	Atmosphere-Land Dynamics of Mercury in a Forest Landscape of the Adirondack Region of New York Charles Driscoll, Syracuse University	
3:40 p.m. to 4:00 p.m.	Break	Sunshine Room
4:00 – 4:20	Development of Surrogate Surfaces for Assessing Dry Deposition of Atmospheric Hg Mae Gustin, University of Nevada, Reno	Canyon Half of Ballroom
4:20 – 4:40	Plume-in-Grid Modeling of Atmospheric Deposition of Mercury over the U.S. Krish Vijayaraghavan, Atmospheric & Environmental Research, Inc.	

Wednesday, September 12, 2007

Room Location

Technical Session:

TOTAL MERCURY DEPOSITION (CONTINUED)

Session Chairs: Eric Prestbo

Tekran Corporation

David Gay

Illinois State Water Survey

Canyon Half of
Ballroom

4:40 – 5:00

**Understanding Relationships between
Mercury Concentrations and Certain Water
Quality Characteristics: Biogeochemical
Cycling of Mercury and Methyl Mercury in
Great Smoky Mountains National Park**

Suzanne Fisher, Tennessee Valley Authority

5:00 – 5:20

**Mercury Mass Balance in Decomposing
Leaf Litter**

Kathleen Knight, University of Connecticut

2007 NADP SITE OPERATOR AWARDS

National Trends Network Operator Awards

Site	Operator Name	Site Name	Wet Start	Agency
5-Year Awards				
GA33	Aimee Gaddis	Sapelo Island	Nov-02	NSF/UGS, NOAA-NERR, & GA Department of Natural Resources
KY10	Johnathan Jernigan	Mammoth Cave National Park-Houchin Meadow	Aug-02	National Park Service-Air Resources Division
MI48	Gary Heet	Seney National Wildlife Refuge-Headquarters	Nov-00	US Fish & Wildlife Service-Air Quality Branch
MI48	Marilyn Heet	Seney National Wildlife Refuge-Headquarters	Nov-00	US Fish & Wildlife Service-Air Quality Branch
MT97	Tanya Niedhardt	Lost Trail Pass	Sep-90	USDA Forest Service
NC29	Joe Jarman	Hofmann Forest	Jul-02	North Carolina State University
NE15	Ed Cunningham	Mead	Jul-78	SAES-University of Nebrask
NY01/NY65	Wes Bentz	Alfred/Jasper	Aug-04	US Geological Survey
SD04	Marc Ohms	Wind Cave National Park-Elk Mountain	Nov-02	National Park Service-Air Resources Division
VA99	Ken Hickman	Natural Bridge Station	Jul-02	Virginia Department of Environmental Quality
WI36	Therese Hubacher	Trout Lake	Jan-80	Wisconsin Department of Natural Resources
10-Year Awards				
MN08	Mary Jo Flack	Hovland	Dec-96	Minnesota Pollution Control Agency
MT00	Wayne Not Afraid	Little Bighorn Battlefield National Monument	Jul-84	US Geological Survey
MT98	Jeff Whitmus	Havre - Northern Agricultural Research Center	Jul-85	US Geological Survey
NC36	Paul Anderson	Jordan Creek	Oct-83	US Geological Survey
OR09	Rick Elston	Silver Lake Ranger Station	Aug-83	US Geological Survey
PA72	Lynn Dennis	Milford	Dec-83	USDA Forest Service
VT99	Miriam Pendleton	Underhill	Jun-84	US Geological Survey

National Trends Network Operator Awards

Site	Operator Name	Site Name	Wet Start	Agency
15-Year Awards				
AK03	Andrea Blakesley	Denali National Park-Mt. McKinley	Jun-80	National Park Service-Air Resources Division
MA08	Daniel Pepin	Quabbin Reservoir	Mar-82	Northeast States for Coordinated air Use Management
MT13/MT96	Linda Connor	Poplar River	Feb-82	Northeast States for Coordinated air Use Management
WY99	Rod Randall	Newcastle	Aug-81	Bureau of Land Management
20-Year Awards				
FL41	April Ammeson	Verna Well Field	Aug-83	US Geological Survey
KS31	Rosemary Ramundo	Konza Prairie	Aug-82	SAES-Kansas State University
KY22	Robert Watts	Lilley Cornett Woods	Sep-83	NOAA-Air Resources Lab
MT00	Les Frickle	Little Bighorn Battlefield National Monument	Jul-84	US Geological Survey
NC25	Robert McCollum	Coweeta	Jul-78	USDA Forest Service
UT98	Nolan Johnson	Green River	Apr-85	US Geological Survey

Mercury Deposition Network Operator Awards

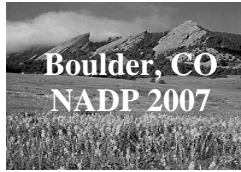
Site	Operator Name	Site Name	Wet Start	Agency
10-Year Awards				
GA09	Ron Phernetton	Okefenokee National Wildlife Refuge	Jul-97	US Fish & Wildlife Service-Air Quality Branch
ME02	Peter Lowell	Bridgton	Jun-97	EPA/Maine Department of Environmental Protection
WI99	Ted Peters	Lake Geneva	Jan-97	Wisconsin Department of Natural Resources

Atmospheric Integrated Research Monitoring Network Operator Awards

Site	Operator Name	Site Name	Wet Start	Agency
10-Year Award				
VT99	Miriam Pendleton	Underhill	Jul-93	NOAA-Air Resources Lab
15-Year Awards				
IL11	Michael Snider	Bondville	Oct-92	NOAA-Air Resources Lab
NY67	Tom Butler	Ithaca	Sep-92	NOAA-Air Resources Lab
TN00	Mark Brewer	Walker Branch Watershed	Sep-92	NOAA-Air Resources Lab

TECHNICAL SESSION: TOTAL NITROGEN DEPOSITION

Session Chair: Rick Artz, NOAA – Air Resources Lab



Is There More to Total Deposition Than Wet and Dry: Lessons From and Utility of Throughfall

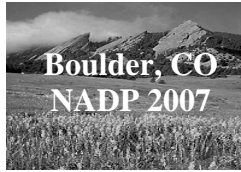
Kathleen C. Weathers
Institute of Ecosystem Studies
Box AB, Millbrook, NY 12545

There are two methods that have commonly been used to estimate total deposition: 1) measured (wet) combined with modeled (dry and cloud) deposition from monitoring networks, and 2) the measurement of throughfall flux (TF), which is a measure of total deposition (wet + dry + fog or cloud) as well as the net result of uptake and leaching to the forest floor. The TF method has the advantages of being inexpensive and integrating deposition over complex forest canopies and/or complex terrain, which are the landscapes where model assumptions for calculating dry and fog deposition fluxes are tenuous, at best. The monitoring data allow site-to-site comparisons and accurate flux numbers for regions adjacent to monitoring station locations.

Throughfall compares well to CASTNET + NADP sulfur (S) and nitrogen (N) deposition for forests adjacent to CASTNET sites. It also compares well to cloud+wet+dry deposition as measured by MADPro, CASTNET and NADP. Over the past several years, complementary uses of throughfall and monitoring network data have emerged for estimating total deposition to complex terrain. Here, I illustrate the upsides and downsides of throughfall measurements and how they have been used for estimating the deposition of N and S over complex terrain and across regions.

The addition of throughfall measurements to routine monitoring may enhance the utility of NADP, CASTNET and MADPro monitoring, for pollutants, including metals, and nutrients.

*Corresponding author – E-mail: weatherk@ecostudies.org



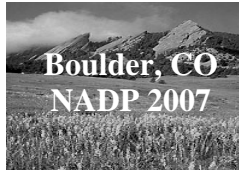
Results of the Southern Ontario Ammonia Passive Sampler Survey (SOAPSS)

Mike Shaw*, Bob Vet, Dave MacTavish, Gary Beaney,
Nancy Lance, Bill Sukloff, and Amy Hou
Environment Canada, Air Quality Research Branch,
4905 Dufferin Street, Toronto, Ontario, Canada M3H 5T4

The Southern Ontario Ammonia Passive Sampler Survey (SOAPSS) ran from April 4, 2006 to March 27, 2007. The objective of the study was to measure weekly/biweekly concentrations of ambient ammonia at approximately 78 sites in southern Ontario and at a small number of sites outside of Ontario and in the northern Great Lakes states. Eleven NADP and CASTNET sites kindly collaborated in the study, providing site access and operator support. Two types of passive samplers and two sampling periods were used. From April 4 to November 21, 2006, weekly sampling was carried out using Ogawa passive samplers at sites in the agricultural areas and P25 passive samplers (a customized larger version of the Ogawas) in the non-agricultural areas; after November 21, 2006, bi-weekly sampling was done in all areas using the P25s only. Both types of passive samplers were collocated at several sites for comparison and, at one site, also collocated with a continuous ammonia monitor and a denuder/filter pack system.

Results of the study confirm that ambient ammonia concentrations are high in the intense agricultural areas of southwestern Ontario and low in the non-agricultural areas of south-central and southeastern Ontario. In fact, the spatial pattern of SOAPSS ambient ammonia concentrations corresponds closely to the pattern of ammonia emissions. Southwestern Ontario concentrations, although high for eastern Canada, were lower than those measured in the intensive agricultural areas of western Canada (i.e., in British Columbia, Alberta and Manitoba). Concentrations measured at the U.S. NADP and CASTNET sites were generally in the same low concentration range as the Ontario sites, with the exception of the Aurora, NY site, which had relatively high concentrations. A full summary of SOAPSS results will be given.

*Corresponding author - Telephone: 416-739-4456; E-mail: mike.shaw@ec.gc.ca

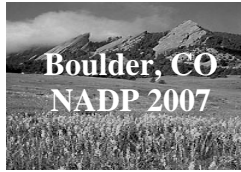


**Model Estimated Components of Oxidized Nitrogen Dry Deposition Not Covered
By the Networks, with a Focus on Urban Deposition**

Robin L. Dennis
NOAA/ARL, In Partnership with EPA/ORD
Atmospheric Modeling Division
US EPA, MD 243-04
Research Triangle Park, NC 27711

We already know we are missing a major fraction of reduced nitrogen deposition in our budget estimates by not measuring NH_3 concentrations and not estimating NH_3 dry deposition in the networks. We are also missing components of dry oxidized nitrogen (ox-N) deposition that are important to regional budgets and critical to urban deposition budgets. Wet deposition is more regional in character with no strong urban signal. Dry deposition shows a very strong urban signal. The degree to which we are missing deposition budgets will be illustrated with a high resolution (2 km grid) CMAQ study of Tampa and St. Petersburg, Florida, which have high population density. In regional and rural areas modeling suggests dry deposition of ox-N (stemming from NO_x emissions) is modestly greater than wet deposition (factor of 1.5 for Chesapeake Bay watershed). In regional budgets ox-N deposition is primarily total-nitrate with a modest contribution from NO_x , PANs and organic nitrate. In urban areas modeling suggests that dry deposition of ox-N is many times greater than wet deposition (factors of 2-10 and higher). In urban budgets, ox-N dry deposition is principally due to NO_x deposition with a modest contribution from total-nitrate, even though the urban total-nitrate deposition is enhanced compared to its rural deposition. The relative contributions of NO_x and total-nitrate to ox-N dry deposition are mirror images of each other across urban and regional space. Dry deposition budget numbers will be provided for the Tampa and St. Petersburg area to illustrate the effect of a strong urban signal and provide insight into the different sources of ox-N deposition. Currents networks are blind to this signal, both in terms of location of sites and species measured. With urban growth and fill-in, this signal will increase in importance and the delivery of N to coastal waters per unit of NO_x emissions is expected to increase.

*Corresponding author – Telephone: 919-541-2870; E-mail: Robin.Dennis@noaa.gov

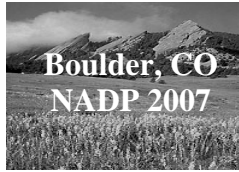


Modeling Nitrate Concentrations and Deposition: Sensitivities to Cloud Treatment and Landuse

Alice Gilliland*, Shawn Roselle, Jon Pleim, and Prakash Bhawe
NOAA Atmospheric Sciences Modeling Division
In partnership with USEPA
USEPA Mailroom E243-01
109 T.W. Alexander Drive
Research Triangle Park, NC 27711

Past evaluations of the Community Multiscale Air Quality (CMAQ) model have shown notable over predictions of nitrate aerosol and total nitrate concentrations under winter conditions. Much work has been done to refine heterogeneous chemical pathways, thermodynamic equilibrium models, and ammonia emission estimates; however, over prediction biases are still evident. Recent model tests for winter 2002 have identified key meteorological model sensitivities that are affecting the total nitrate concentrations and deposition of nitrate. Using two different microphysics schemes with the MM5 meteorological model, the CMAQ model predictions of wet deposition varies by approximately 25% while precipitation volume is only negligibly different. Additional analysis has shown large differences in the nitric acid dry deposition velocities from these two MM5 simulations, which appears to be related to differences in the landuse data and resulting surface roughness and aerodynamic resistance estimated for CMAQ. Sensitivities of total nitrate concentrations and deposition to these factors are quite large. More detailed evaluation of the total nitrate budget needs to be conducted using various meteorological model options with particular attention to the cloud and landuse impacts.

*Corresponding author – Telephone: 919-541-0347; E-mail: alice.gilliland@noaa.gov or gilliland@epa.gov



Nitrogen Isotopes in Dry Deposition: Can CASTNET and Passive Samplers be Used to Partition Contributions of NO_x Sources?

E. M. Elliott*, C. Kendall¹, E. W. Boyer², D.A. Burns³, G. Lear⁴

Nitrate isotopes in wet deposition are useful indicators of NO_x source contributions to nitrate formation and NO_x oxidation pathways¹. Here we examine whether nitrogen and oxygen isotopes ($\delta^{15}\text{N}$ and $\delta^{18}\text{O}$, respectively) in dry deposition provide similarly useful information using dry deposition fractions collected from: 1) CASTNET samplers (nitric acid (HNO₃) and particulate nitrate (NO₃⁻)); and 2) passive diffusion samplers (nitrogen dioxide (NO₂), ammonia (NH₃), and HNO₃).

We present the first regional scale analyses of the isotopic composition of dry deposition using CASTNET samples from 8 sites in New York, Pennsylvania, and Ohio. Weekly samples were pooled into monthly composites from April 2004-April 2005 and both HNO₃ and particulate NO₃⁻ fractions were analyzed for $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$. We observed distinct spatial and temporal patterns in both $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ of HNO₃ and particulate NO₃⁻. Potential causes for these patterns will be explored by comparing the CASTNET isotope data with the distribution of major NO_x emission sources, as well as with volume-weighted monthly precipitation samples collected simultaneously at co-located NADP sites.

In addition, we examine the efficacy of using passive diffusion samples to assess the isotopic composition of various atmospheric N sources, and their utility for assessing multiple source contributions to individual sites. Passive diffusion samplers were deployed for up to one month to collect NH₃, NO₂, and HNO₃ in various settings across New York. The deployment environments included parking garages, urban areas, vehicle tailpipes, agricultural areas, and confined animal feedlots. Preliminary results of $\delta^{15}\text{N}$ in these deposition fractions will be presented, with a focus on the potential for separating source contributions to dry N deposition. Further, knowledge gaps necessitating additional work will be identified and presented. Finally, using a synthesis of these data sets, we will present isotopes of wet and dry deposition as a potential method for distinguishing source contributions to individual sites, and for monitoring long-term reductions in source contributions associated with the Clean Air Interstate Rule (CAIR).

*Corresponding Author - University of Pittsburgh, Department of Geology & Planetary Science, 200 SRCC Building, 4107 O'Hara Street, Pittsburgh PA 15260 Telephone: 412-624-8882;

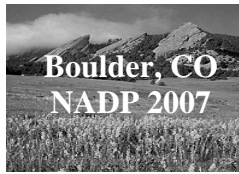
E-mail: eelliott@pitt.edu

¹USGS, Menlo Park

²University of California, Berkeley

³USGS, Troy

⁴US EPA, Clean Air Markets Division

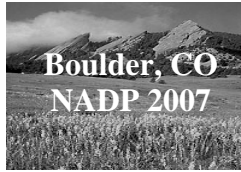


Detecting Past and Future Trends in Nitrogen Deposition: A Modeling Study to Guide the Placement of Future Monitoring Sites

Robert W. Pinder, Alice B. Gilliland, Robin L. Dennis
ASMD, NOAA, ALR, RTP, NC, 27711
In partnership with NERL, USEPA

Previous studies have reported large changes in concentrations and deposition fluxes observed in the national monitoring networks (NADP, CASTNet, and STN). However, as the focus of regulated emission reductions turns from SO₂ to NO_x, it is important to re-assess the location of the network monitoring sites to ensure sufficient coverage in order to evaluate the effectiveness of the regulated emission changes. This research examines the sensitivity of monitored concentrations and deposition fluxes to emission changes for two cases: (1) previous emission reductions during the NO_x SIP call (2002 – 2005) and (2) future projected emission changes planned for the Clean Air Interstate Rule (2010 and 2020). To estimate this sensitivity, we use the Community Multiscale Air Quality (CMAQ) model. First, using the well-known emission changes of the NO_x SIP Call, we evaluate the CMAQ model predicted sensitivity using monitoring network observations of concentration and deposition for that time period. Second, we apply CMAQ to estimate concentrations and deposition for the future years of 2010 and 2020 in response to the Clean Air Interstate Rule. By the year 2020, after substantial reductions in SO₂ and NO_x emissions, we estimate large changes in the composition and spatial extent of inorganic aerosol. This causes a highly variable change in the spatial distribution of reduced nitrogen (NH₃ + NH₄⁺) deposition. Given only current monitoring network locations and speciation, this change will not be well quantified.

DISCLAIMER: The research presented here was performed under the Memorandum of Understanding between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and under agreement number DW13921548. This work constitutes a contribution to the NOAA Air Quality Program. Although it has been reviewed by EPA and NOAA and approved for publication, it does not necessarily reflect their policies or views.



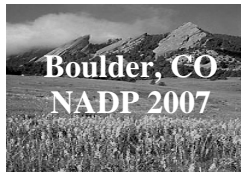
Semiempirical Model Estimates of Ammonia Dry Deposition to North Carolina Coastal Watersheds

John T. Walker^{*1}, Rob Austin², Sue Kimbrough¹, and Wayne Robarge²

In this poster we present a new method for predicting ambient NH₃ concentrations and bi-directional air-surface exchange at field to watershed scales in areas where animal production intensity is high. For development and initial testing, which includes the results presented, the model domain includes the Neuse and Cape Fear River basins in eastern North Carolina. This region of the state contains some of the highest county-scale NH₃ emissions in the U.S. The model incorporates a facility-scale NH₃ emissions inventory from which ground-level ambient NH₃ concentrations are predicted as a nonlinear function of distance from the nearest source. Ammonia air-surface exchange rates are determined using a two-layer canopy compensation point model that takes into account differences in soil, vegetation, and water emission potential, as well as surface physical characteristics, for primary land use categories. Model output includes NH₃ emissions from agricultural point sources, atmospheric concentrations, and net air-surface exchange fluxes at 100 m resolution. The model framework is described and estimates of dry + wet deposition of NH₃ in the Cape Fear and Neuse River basins are presented.

^{*1}Corresponding author – U.S. EPA, National Risk Management Research Laboratory
Research Triangle Park, NC 27711 Telephone: 919-541-2288; E-mail: walker.johnt@epa.gov

²North Carolina State University, Department of Soil Science Raleigh, NC 27695



What Modifications in the National Deposition Monitoring Networks are Required to be Able to Measure and Source Apportion Representations of All Reactive Nitrogen Species?

William C. Malm^{*1}, Jeffrey L. Collett, Jr.², and Bret A. Schichtel¹

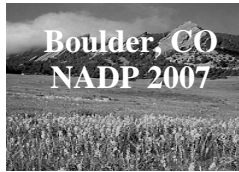
Deposition of nitrogen compounds can cause a number of deleterious effects, including changes in ecosystem function and surface water chemistry. The national deposition monitoring networks, measuring concentrations of certain molecular species in both their wet and dry forms, have been successful in furthering our understanding of ambient aerosols and selected trace gases across the United States; however, they also have important shortcomings. Key shortcomings of the current monitoring systems are their temporal resolution (one-week integrated samples), the accuracy of the split between ambient nitric acid and particulate nitrate, that NH_3 is not measured, and that organic nitrogen (ON) is not routinely measured, either as total or speciated ON, in any of its wet, gaseous, or particulate forms. Organic nitrogen has been shown to contribute significantly to the total nitrogen deposition budget. Although some work has been done to characterize total ON in the atmosphere, little effort has been expended to characterize the molecular forms of ON, much less their origin. Measurements of the contribution of ON to total nitrogen in rain water in North American range from 10% to 60% with an average of 38%. Ambient measurements of particulate ON at a few locations show that it can make up about 30% of particulate organic material, while measurements of aliphatic amines concentration near animal husbandry activities have shown them to be as high as ammonia. Oxidized forms of N such as peroxyacetyl nitrate and related alkyl nitrates have been shown to exist in significant concentrations. This presentation will review which of the many species contributing to total reactive N deposition can be routinely measured accurately, less accurately, at the research level, and not at all. Recommendations will be made as to what species to measure and with what time resolution to meet the overall objective of measuring and apportioning reactive nitrogen species to their emission sources.

^{*1}National Park Service, CIRA/CSU, Fort Collins, CO 80523

²Department of Atmospheric Science, Colorado State University, Fort Collins, CO 80523

**TECHNICAL SESSION: ECOLOGICAL IMPACTS OF ATMOSPHERIC
 DEPOSITION**

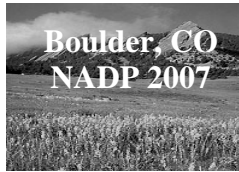
Session Chair: Pamela Padgett, USDA Forest Service



A Reversal of Acidification Recovery Trends in Stream-Water Chemistry in the Catskill Mountain Region of New York

Doug Burns, Watersheds Research Section, U.S. Geological Survey, 425 Jordan Rd.
Troy, New York 12180-8349, daburns@usgs.gov, 518-285-5662

The U.S. Geological Survey has been monitoring stream chemistry and flow at four small watersheds in the Catskill Mountains of New York since the early 1990s; data at some of these streams extends back to the 1980s. These streams are located in the highest elevation terrain in this region where thin soils, steep slopes, and resistant bedrock with low base cation availability combine to provide little neutralization to acid deposition. The monitored streams span a pH range of about 4.8 to 6.3 and an acid-neutralizing capacity (ANC) range of 30 to -25 $\mu\text{eq/L}$ at baseflow, and all four stream reach negative ANC values during high flow with elevated aluminum concentrations. The pH of precipitation in this region has been increasing by about 0.01/yr since the early 1990s according to data from the Biscuit Brook NTN site (NY68). This increase in precipitation pH is broadly consistent with trends at other NTN sites in the Northeast, and is driven largely by decreases in sulfate concentrations as a result of implementation of Title IV of the Clean Air Act Amendments of 1990. Two previous studies of trends in stream-water chemistry at these four sites have found a pattern of increasing pH and ANC and decreasing sulfate concentrations during 1992 – 2001, and 1992 - 2003. These trends are consistent with the decreasing trends in precipitation acidity in this region, and the trends were expected to persist as precipitation acidity continued to decrease during 2003 – 2006. Instead, the trends in pH and ANC are no longer significant over the period 1992 - 2006, as nitrate concentrations have increased during 2004 – 2006 to nearly unprecedented values. These recent increases in stream nitrate are believed to be related to defoliation by the Forest Tent Caterpillar that was observed during this period, and is known to have greatly affected the Catskills during 2004 – 2006. Previous studies have found that insect defoliation diminishes uptake of nitrogen by trees and the frass provides a source of readily nitrified organic matter to the forest floor. These results indicate that regional recovery of stream chemistry has thus far been so slight, that disturbances to the nitrogen cycle can disrupt the recovery trend. Disturbances such as that by defoliating insects can delay stream recovery for at least several years, and possibly longer if the intensity and duration of attack is great enough to cause significant tree mortality.



Effects of Acid Rain on the Chemistry of Western Adirondack Streams In 2003-2005

Gregory B. Lawrence^{*1}, Karen M. Roy², Barry P. Baldigo¹, Howard A. Simonin³, Susan B. Capone⁴, James W. Sutherland⁵, Sandra A. Nierzwicki-Bauer⁶, and Charles W. Boylen⁶

A focus on lake chemistry has resulted in an incomplete picture of acidic deposition effects on surface waters in the Adirondack region of New York. Relatively little information is available on streams in this region, although they are more prone to acidification, particularly during high flows. An assessment of streams was therefore undertaken in the Oswegatchie and Black River drainages; an area of 4585 km² in the western part of the Adirondack region of New York. Streams with lakes or ponds that affected more than 25 percent of their drainage area, or required more than 1 hour of hiking to reach were excluded. Of the 565 streams that met these criteria, 200 were randomly selected for sampling. Sampling surveys were conducted on 3 to 4 consecutive days, twice during spring snowmelt (March 29-April 1, 2004 and March 29-31, 2005), twice during summer base flows (August 25-29, 2003 and August 16-18, 2004) and once during fall storms (October 27-30, 2003).

Acidification was assessed with the newly developed base-cation surplus (BCS) and acid-neutralizing capacity by Gran titration (ANC_G). The BCS was more effective for ascribing acidic deposition effects than ANC_G, because it related more closely to concentrations of inorganic Al. The percentage of streams with a BCS value < 0 $\mu\text{eq L}^{-1}$, averaged for the five surveys, was 38 percent, compared with 18 percent with ANC_G < 0 $\mu\text{eq L}^{-1}$. The BCS percentage is consistent with the finding that 31 percent of streams (averaged for all surveys) had a concentration of inorganic Al > 2.0 $\mu\text{mol L}^{-1}$, the level above which is toxic to brook trout, a relatively acid-tolerant fish species. These results demonstrated that the criterion for acidification of ANC_G < 0 is not suitable for the protection of aquatic biota.

During elevated flows in March 2004, 56 % were acidified based on the criterion of BCS < 0 $\mu\text{eq L}^{-1}$, whereas during low flows in August 2003, 12% were acidified. The total length of stream reaches estimated to be prone to acidification within the study area was 718 km, although a remaining 3085 km were not assessed because of inaccessibility.

^{*1}Corresponding author – USGS, 425 Jordan Rd., Troy, NY 12180; E-mail: glawrenc@usgs.gov, bbaldigo@usgs.gov.

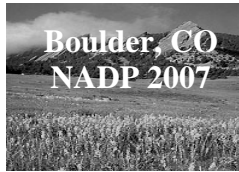
²New York State Dept. of Environ. Cons., Box 296, Ray Brook, NY, 12977; E-mail: kmroy@gw.dec.state.ny.us

³New York State Dept. of Environ. Cons., 8314 Fish Hatchery Road, Rome, NY, 3440; E-mail: hasimoni@gw.dec.state.ny.us

⁴Adirondack Lakes Survey Coop., Box 296, Ray Brook, NY, 12977; sbcapone@gw.dec.state.ny.us

⁵P.O. Box 2641, Nantucket, MA, 02584; E-mail: jwsinack@comcast.net

⁶Darrin Fresh Water Inst. and Dept. of Biology, Rensselaer Polytechnic Inst., 110 8th St. Troy, NY, 12180; E-mail: nierzs@rpi.edu; boylec@rpi.edu



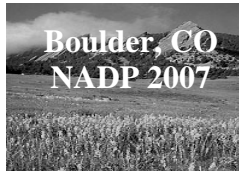
Regional Estimates of Contaminant Deposition in Aquatic Ecosystems

Frank H. McCormick, Ph.D.
US Forest Service
Environmental Sciences Research
c/o Olympia Forestry Sciences Laboratory
3625 93rd Ave. SW, Olympia, WA 98512

We evaluated the extent of contamination of fish in the Mid-Atlantic Region as part of the U.S. Environmental Protection Agency's Monitoring and Assessment Program's regional assessment in 1993 through 1998 and in the Western United States in 2000 to 2004. Fish assemblages from wadeable streams were dominated by small, short-lived fishes (e.g., minnows, darters, and sculpins) that were more widely distributed and abundant than large fishes typically chosen for tissue contaminant studies (e.g., trout, black bass, sunfish, common carp). Chemical concentrations in whole-fish homogenates exceeded detection limits for mercury, DDT, and polychlorinated biphenyls (PCBs) in 75 to 100% of the stream length assessed using small fishes and 84 to 100% of the stream length assessed using large fishes. We developed wildlife values (WVs) representing a threshold for toxic effects to allow examination of the spatial extent of potential risk to piscivorous wildlife. For mercury, DDT, dieldrin, and chlordane, estimates of the regional extent of streams where fish contaminant concentrations exceeded the WVs were greater when based on small fishes than on large fishes.

Using stable isotope analysis, we are investigating pathways of contaminant deposition and incorporation into aquatic ecosystems.

*Corresponding author – Telephone: OFSL 360-753-7667 and WO 703-605-4184;
E-mail: fmccormick@fs.fed.us



Predicting Change in Nitrogen Loading to Escambia Bay due to Additional Point Source Controls on a Nearby Power Plant

Michele Cutrofello*¹, Jo Ellen Brandmeyer¹, Stephen Beaulieu¹, Randy Dodd¹, Justin T. Walters², John J. Jansen², and Krish Vijayaraghavan³

Pollution controls for NO_x and SO₂ are being installed at a power plant located near Escambia Bay in the Florida panhandle. The control technology is expected to change both the mass and species of nitrogen emitted to the atmosphere and, ultimately, reduce the nitrogen loading to the bay. The purpose of this modeling study was to estimate the difference in total nitrogen loading to the bay between the “no controls” and “controls” scenarios.

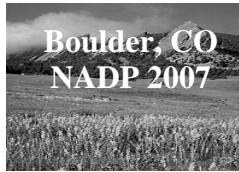
Wet and dry deposition of nitrogen species were simulated in a companion study using three configurations of the Community Multi-scale Air Quality (CMAQ) model and one configuration of the CALPUFF air dispersion model. An air quality simulation was performed for each scenario and each model configuration, resulting in eight sets of modeling results as inputs for the watershed modeling. The total nitrogen load to the bay attributable to plant emissions was the sum of (1) the direct deposition to Escambia Bay and (2) transport to the bay following deposition to the watershed.

In the initial set of watershed modeling runs, the nitrogen transfer following deposition to the watershed was calculated using a screening-level model based on EPA’s Pollutant Loading Model to provide a rapid estimate of the nitrogen load. The screening model provided a conservative estimate of the actual nitrogen load to the bay; that is, the model was set up and parameterized to ensure that the nitrogen load to the bay would not be underestimated. In the second set of watershed modeling runs, a more mechanistic model was used to improve the accuracy of nitrogen loading estimates to the bay. The ReNuMa (Regional Nutrient Management) Model developed by Cornell University was modified to use daily wet and dry atmospheric deposition fluxes of total nitrogen specific to land uses in the watershed. Following deposition, the model simulated a series of physical and chemical processes (e.g., soil retention; denitrification), and the loads from each watershed were routed from each watershed outlet to determine the total load to the bay. The contribution from atmospheric deposition, non-point source runoff, and point sources within each watershed was determined for both the screening and ReNuMa modeling runs.

This paper presents the methodology used to (1) estimate the total nitrogen from nitrogen species predicted by the atmospheric models, (2) calculate loads to the bay using the total nitrogen estimates, and (3) determine the change in nitrogen loading to the bay associated with emissions controls. Thus, the methodology is intended to fully support the evaluation of ecological benefits associated with changing nitrogen loads to the bay. In addition, the paper also describes how monitoring data were used to calibrate the watershed models and to measure model performance. We present ideas for how additional monitoring data could be used in this type of study to improve model performance.

*¹Corresponding author – RTI International, 3040 Cornwallis Road, Research Triangle Park, NC 27709: Telephone: 202-974-7838; E-mail: mcutrofello@rti.org ²Southern Company, 600 N. 18th St., 14N-8195, Birmingham, AL 35203

³Atmospheric & Environmental Research, Inc., 2682 Bishop Dr, Ste 120, San Ramon, CA 94583



Investigating the Effects of Nitric Acid on *Ramalina menziesii* Tayl.

Jennifer Riddell¹, Pamela Padgett², Thomas H. Nash III¹

Lichens have been used as biomonitors of changes in air quality for over a century and a half. Naturalists in industrializing Europe noted the loss of lichen species and dubbed it the “city effect,” later connecting the disappearances with SO₂ pollution. The differential responses that lichen species have to pollutants have allowed biologists to develop biomonitoring programs that use inventories of community composition in potentially effected areas and compare them to baseline data or predicted community makeup. Based on current knowledge, presence or absence of particular species can indicate levels of NH₃ or SO₂ pollution, but little is known about community responses to ozone and HNO₃.

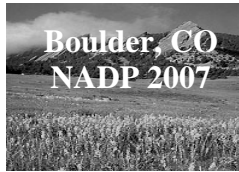
Surveys in the mountains of the LA air basin in the 1980’s showed that approximately 50% of the lichen species collected in the early 1900’s were extirpated, and many extant species had declined in abundance as well as showing signs physical damage. A 2004 resurvey in the San Bernardino Mts. showed further decline in the abundance of formerly tolerant species. The researchers who described this phenomenon found that ozone concentration gradients overlaid the patterns of species extirpation. More recent research in the air basin has shown that nitric acid deposition gradients run parallel to the ozone concentration gradient, and that nitrate and nitric acid can have significant effects on forest health. In the Los Angeles (LA) air basin, air quality has been a concern for more than 35 years, and nitrogen dry deposition rates in forests downwind of the urban areas can reach 35-40 kg ha⁻¹ year⁻¹, exceeding currently understood critical loads.

Our research examines the effects of nitric acid dry deposition on the lichen *Ramalina menziesii* Tayl. in an effort to understand the significant loss of species in southern California, and increase the usefulness of lichens as biomonitors of nitrogen pollutants.

We transplanted healthy *R. menziesii* thalli from the UCSB Sedgwick Reserve, north of Santa Barbara, CA, into constantly stirred fumigation chambers in a climate-controlled greenhouse at UCR, Riverside, CA, containing varying levels of gaseous nitric acid. *Ramalina menziesii* thalli treated with nitric acid in month-long fumigations show a marked decline in chlorophyll content and carbon exchange capacity compared to thalli in control chambers. The leachate conductivity, nitrate and potassium concentrations increased with nitric acid fumigation levels and time, while sodium content decreased with time, not exposure. We conclude that *R. menziesii* has an unequivocally negative response to nitric acid gas concentrations common to ambient summer conditions in the LA air basin. Our next line of investigation will examine the threshold concentrations of damage to lichen physiology using several species, as well as responses to factorial fumigations with O₃ and HNO₃.

¹*Corresponding author - Arizona State University School of Life Sciences, PO Box 874601, Tempe AZ 85287 Telephone: 480-965-7735; E-mails: jennifer.riddell@asu.edu, tom.nash@asu.edu

²USDA F.S. Pacific Southwest Research Station, 4955 Canyon Crest Drive, Riverside, CA 92507 Telephone: 951-680-1584; E-mail: ppadgett@fs.fed.us



Understanding the Interactive Effects of Nitrogen Deposition, Global Warming, and Increased Snowfall on the Encroachment of Woody Shrubs into the Alpine Tundra

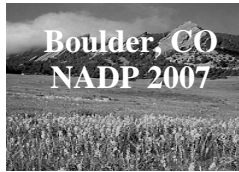
Isabel W. Ashton*, Jane G. Smith, Marko Spasojevic, and Katharine N. Suding

Alpine ecosystems are highly sensitive to nitrogen (N) deposition, recent warming temperatures, and changes in snowpack. Alpine plants are particularly threatened by local and regional extinction as they are replaced by species from lower elevations. Concurrent with global warming and increasing N availability, there has been an increase in the abundance and distribution of woody shrubs, particularly *Salix spp.*, in alpine zones and positive feedbacks among temperature, snowpack, and nutrient availability are predicted to accelerate this shrub encroachment; however the exact mechanisms by which warmer temperatures favor the spread of shrubs over herbaceous plants remains unclear. In 2006, we began a factorial experiment involving the manipulation of air temperature, soil temperature, and snowpack within the moist meadow alpine at Niwot Ridge LTER. Growing season temperatures have been increased 1-2° C above ambient using open-topped chambers, N has been added at a rate of 8 g m⁻² yr⁻¹ and snow fences have increased snow pack and maintained warmer winter soil temperatures. To test the hypothesis that the survival, growth, and reproduction of *Salix* is favored by N, warmer temperatures, and increased snow pack we have monitored *Salix* survival and growth and compared this to the tundra community. Our preliminary data show that *Salix* survival is greater in warmed plots, suggesting that increased global temperatures may drive woody encroachment into the alpine. There is a strong interactive effect of N and snow, where *Salix* survival increases with added N, but decreases with added N and snow. It is critical to understand such interactive effects of N deposition and other global changes in order to predict and prevent further conversion of alpine tundra to shrublands.

*Corresponding author - Department of Ecology and Evolutionary Biology, University of California, Irvine, 321 Stenihaus Hall, Irvine, CA 92697-2525 Telephone: 303-492-8841; E-mail: iashton@uci.edu

**TECHNICAL SESSION: CLIMATE CHANGE/GREENHOUSE GAS
MITIGATION**

Session Chair: Angela Zahniser, Bureau of Land Management

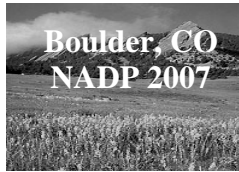


Emerging Climate Change Science and Policy

Jason Samenow
EPA Office of Atmospheric Programs
Climate Change Division
1200 Pennsylvania Ave, NW 6205J
Washington, DC 20460

New science and policy developments within the last year have brought about significant change in EPA's work on the climate change issue. The Collective actions of the legislative, judicial, and executive branches have prompted EPA to analyze the benefits of different climate response strategies. EPA's Climate Change Division (CCD) is providing technical support for these activities, utilizing salient findings from newly released scientific assessments from the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Climate Change Science Program (CCSP). This presentation will summarize the current state of affairs, describe CCD's role in supporting climate policy at the EPA and possible future directions.

*Corresponding author – Telephone: 202-343-9327; E-mail: samenow.jason@epa.gov



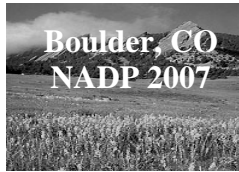
Our Changing Climate: The Underlying Role of Biogeochemistry

Elisabeth A. Holland
Senior Scientist and Program Head
Biogeosciences Program
National Center for Atmospheric Research, Boulder, CO

Climate Change 2007: The Physical Science Basis, Working Group 1 (WG1) the Fourth Assessment Report of Intergovernmental Panel on Climate Change was released earlier this year and has generated world-wide attention. I will review key conclusions of this report, focusing on Chapter 7, Couplings Between Changes in the Climate System and Biogeochemistry. This was the first IPCC report to take an explicit look at the global nitrogen cycle and addresses the relevance of atmospheric deposition measurements to the climate system. I will address the interactions between the carbon and nitrogen cycles, including atmospheric N deposition, including some exciting recent results produced with the NCAR Community Climate System Model run with interactive Biogeochemistry.

The WG1 Summary for Policy Makers (SPM) includes the following excerpts: "The understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report (TAR), leading to *very high confidence* that the globally averaged net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m⁻². Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture. Carbon dioxide is the most important anthropogenic greenhouse gas. Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Eleven of the last twelve years (1995 -2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). Paleoclimate information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1300 years. The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 meters of sea level rise. Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations. Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns."

*Corresponding author – Telephone: 303-497-1433; E-mail: eholland@ucar.edu



Impacts of Climate Change and Global Emissions on PM_{2.5} and Ozone Levels in the United States: A Sensitivity Assessment and Development of an Integrated Modeling Framework

Peter J. Adams^{*1,2}, John P. Dawson^{2,3}, Pavan Nandan Racherla²,
Barry H. Lynn⁴, and Spyros N. Pandis^{3,5}

Future changes in climate and global pollutant emissions provide additional challenges to air quality management in the US. Changes in meteorological variables including temperature, clouds, precipitation, wind speed, circulation patterns will impact PM_{2.5} and ozone concentrations in the US via changes in chemical reaction and photolysis rates, gas-aerosol partitioning, dry and wet deposition, pollutant transport, and emissions of climate-sensitive species such as isoprene. Numerous questions arise. How much will climate change affect US air quality over the next half century? How will its impacts compare to those arising from domestic emissions changes and intercontinental transport of pollution globally? Which meteorological variables and physical processes are responsible for most of the sensitivity? What are the associated uncertainties in these projections? This talk will summarize answers to these questions arising from a 4-year project undertaken by the authors using a variety of modeling tools. Atmospheric models utilized in this research include a global “unified” model of climate, ozone, and aerosols based on the GISS general circulation model, the MM5 regional meteorological model, and the PMCAMx regional chemical transport model. We have designed a research program to draw on the respective strengths of the individual models. For example, PMCAMx has been used to quantify the sensitivity of ozone and PM_{2.5} to each of a full suite of meteorological variables. We have used the GISS “unified” global model to perform multi-year simulations of future air quality under a variety of realistic future scenarios of climate, domestic and international emissions. Finally, we have developed the Global-Regional Climate Air Pollution Modeling System (GRE-CAPS) by integrating the GISS, MM5, and PMCAMx models. GRE-CAPS performance has been evaluated against present-day observations and applied to study the relative impacts of climate change, intercontinental transport, and domestic emissions on US air quality in the 2050s decade.

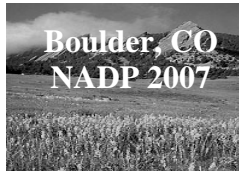
*¹Corresponding author - Department of Civil and Environmental Engineering; Carnegie Mellon University; 5000 Forbes Ave; Pittsburgh, PA 15213 Telephone: 412-268-5624
E-mail: petera@andrew.cmu.edu

²Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA

³Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh, PA

⁴Department of Atmospheric Sciences, The Hebrew University of Jerusalem

⁵Department of Chemical Engineering, University of Patras, Patras, Greece



Carbon Capture and Sequestration: Potential, Challenges, and Outlook

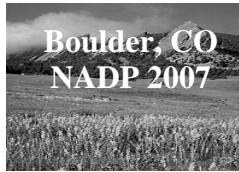
John Venezia
World Resources Institute
10 G Street NE, Suite 800
Washington, DC 20002

Without a major energy technology breakthrough, much of the world will likely continue to rely on relatively cheap and abundant coal to meet our energy needs. One way to use this coal while safeguarding the climate is through carbon capture and sequestration (CCS). CCS involves capturing carbon dioxide (CO₂) from power plants and other industrial processes, transporting it to suitable locations, and injecting it into deep underground geological formations for long-term storage.

However, significant challenges exist before these technologies and practices can be widely deployed in the U.S. and abroad. Incentives and policies will be needed to bring these technologies into the marketplace. Large-scale field projects are needed to prove that we have enough technical and institutional capacity to ensure safe, wide-scale deployment. While a large body of scientific and technical work is underway to overcome barriers to greater deployment of CCS, other policy and regulatory issues need greater attention before the technology can command public support and confidence. Regulatory frameworks will be necessary to govern siting and monitoring of CCS projects, and to establish the long-term liability for CO₂. Finally, public acceptance is still uncertain, yet will be needed before these practices can move forward.

WRI has established a stakeholder partnership between business, government, NGOs, and other parties interested in CCS. We are in the process of developing guidelines for siting, monitoring, and long-term care of projects to ensure that CCS is done safely and effectively. With robust and aggressive guidelines for projects, public confidence in these practices can be gained. WRI is also developing a series of policy briefs to highlight some of the major issues that need to be resolved, such as public acceptability, use of federal lands, and long-term liability.

*Corresponding author - Telephone: 202-729-7715: E-mail: jvenezia@wri.org



Manure-DNDC: Building a Process Based Biogeochemical Tool for Quantifying Ammonia and GHG Emissions and Mitigation Opportunities for California Dairies

William Salas* and Changsheng Li¹

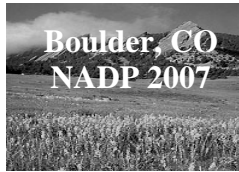
Assessing the environmental impact of manure management is difficult due to high variability in the quality and quantity of animal waste, and in the numerous factors affecting the biogeochemical transformations of manure during storage, treatment and field application. There is an urgent need for scientifically sound, mass balance based, process models for quantifying air emissions from animal feeding operations. Measurement programs are essential, but must be supplemented by process-oriented modeling that incorporates mass balance constraints to extrapolate in both space and time (NRC, 2003). The time is right for moving beyond the inadequate emission factor approach by developing process based models for quantifying air emissions from animal feeding operations.

The dynamics of CH₄, N₂O and NH₃ production/consumption is always controlled by several biochemical and geochemical reactions, namely decomposition, hydrolysis, nitrification, denitrification, ammonium adsorption, chemical equilibriums of ammonium/ammonia, and gas diffusion. These biogeochemical processes are currently simulated in our existing model called DeNitricifation-DeComposition, or DNDC. DNDC simulates these processes under both aerobic and anaerobic conditions, thus is well suited for estimating C and N dynamics and air emissions associated with manure production, storage, treatment and land application.

The current DNDC model has detailed processes for quantifying CH₄, N₂O and NH₃ emissions from agroecosystems with fertilizer/manure application or animal grazing conditions but lacks algorithms for specifying fluxes under drylot, housing and storage conditions. We are now extending DNDC's applications by integrating the fundamental biogeochemical processes with housing and storage management practices. The new developments for our process-based, mass balance approach include (1) integration of detailed biogeochemical processes into the GHG emissions and NH₃ volatilization under drylot, housing or storage conditions; (2) characterization of environmental factors under drylot, housing or storage conditions; and (3) characterization of quantity and quality of dairy waste. This paper provides an overview of our on-going project supported by USDA and California Energy Commission to develop Manure-DNDC modeling system including GIS databases for California dairies, perform a field measurement program and perform model refinements to create a tool for quantifying air emissions from California dairies.

*Corresponding author - Applied Geosolutions, LLC, 87 Packers Falls Road, Durham, NH 03824
Telephone: 603-292-5747; E-mail: wsalas@agsemail.com

¹Institute for the Study of Earth, Oceans and Space, University of New Hampshire, Durham, NH 03824
Telephone: 603-862-1771; E-mail: cs_li@yahoo.com



Impacts of Climate and Land Use Change on Soil Trace Gas Fluxes

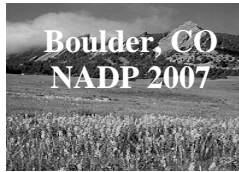
Steve Del Grosso*, Bill Parton¹

Agricultural soils are responsible for the majority of nitrous oxide (N₂O) emissions in the US and are also an important source of ammonia (NH₃) and nitric oxide and nitrogen dioxide (NO_x) emissions. With a global warming potential of ~300 times that of carbon dioxide (CO₂), N₂O is an important greenhouse gas while NH₃ and NO_x contribute to ammonium (NH₄) and nitrate (NO₃) in precipitation. The major factors that control soil trace gas emissions are nitrogen (N) inputs, vegetation cover, soil type, weather, and land management. To address how climate and land use change impact soil trace gas fluxes, the DAYCENT biogeochemical model was used to simulate N₂O, NO₃, and NH₃ emissions for native vegetation and cropping under current climate and projected climate change. Under current climate, DAYCENT estimated N gas emissions are typically 4 to 8 times higher for intensive cropping than for native vegetation. Projecting until the end of the present century, DAYCENT simulations suggest that N gas emissions from corn/soy bean cropping in the central US will be 20-25% higher than under current weather and CO₂ levels. However, the potential to mitigate emissions from agricultural soils is very strong. Recent data from irrigated corn cropping in Colorado suggests that using nitrification inhibitors and time released fertilizer can reduce N₂O emissions by 50% or more compared to application of urea or urea ammonium nitrate, which are the most common forms of N fertilizer. Reduced tillage intensity provides an additional opportunity to mitigate soil greenhouse gas emissions by storing carbon in soil.

*Corresponding author - USDA ARS NPA SPNR, 2150 Centre Ave, Building D, Suite 100, Fort Collins, CO 80526 Telephone: 970-492-7281; E-mail: delgro@nrel.colostate.edu

¹NREL-CSU, 1231 East Drive, Fort Collins, CO 80523 Telephone: 970-491-1987;

E-mail: billp@nrel.colostate.edu



Land Use Carbon Mitigation Options in the Northeastern US

Sarah Walker
Winrock International
1621 North Kent St., Suite 1200
Arlington, VA 22209

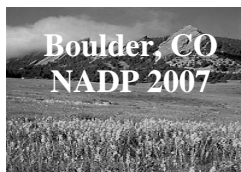
Changing land management practices can result in increased carbon storage, however the potential magnitude of carbon benefits and marginal costs incurred vary spatially and are dependent on the management option that is implemented. The potential increase in carbon storage and associated marginal costs from a variety of management practices on agricultural and forest lands are compared here for the northeastern states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. This comparison allows for an unbiased presentation of the potential quantity and cost of carbon offsets only, other factors beyond the carbon sequestration potential of a particular land management use are outside the scope of this analysis.

Afforestation of agricultural lands can potentially sequester the highest amount of CO₂e per unit area (average 57 t CO₂e/acre after 20 years). Marginal costs vary across the region and for each land management option. Conversion of agricultural cropland to afforestation has the highest marginal costs on average due to high opportunity costs. The afforestation of grazing land has low marginal costs in areas of low hay productivity. Restocking of understocked forest stands and extending rotations in forest lands provide the lowest cost option with the greatest potential carbon mitigation for most counties in the region.

*Corresponding author – Telephone: 703-525-9430; Fax: 703-525-1744;
E-mail: swalker@winrock.org

**TECHNICAL SESSION: DEPOSITION EFFECTS IN ALPINE
ENVIRONMENTS**

Session Chair: Kristi Morris, National Park Service



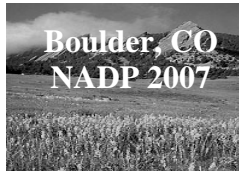
Observations of Airborne Pollutants and Deposition During the 2006 Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS) Study

J. Collett^{*1}, C. Gorin¹, S. Raja¹, C. Carrico¹, T. Lee¹, F. Schwandner¹, D. Day², A. Sullivan¹, G. McMeeking¹, K. Beem¹, S. Kreidenweis¹, J. Hand², B. Schichtel², and W. Malm²

Recent ecological studies have shown a number of deleterious effects due to elevated and increasing deposition of nitrogen compounds in Rocky Mountain National Park (RMNP). The Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS) study was conducted to improve our understanding of the sources and transport of airborne nitrogen and sulfur species within RMNP as well as their deposition pathways. Two field campaigns were conducted, in spring and summer 2006, to characterize pollutant transport and deposition during seasons with historically high nitrogen deposition inputs. Several measurements sites were operated within the park, at locations to the west and east of the park boundaries, and at locations near the northeastern, northwestern, and southeastern boundaries of the state of Colorado. Measurements at several sites included 24-hour integrated gas concentrations (ammonia, nitric acid, sulfur dioxide) PM_{2.5} composition, and wet deposition. A core measurement site in the park included more detailed and higher time resolution chemical, optical, and size distribution measurements. Measurements here included 15 min measurements of PM_{2.5} composition using a Particle Into Liquid Sampler (PILS), a Micro Orifice Uniform Deposition Impactor (MOUDI), a suite of 5 minute gas measurements, a nephelometer, and measurement of particle size distributions over the range 40 nm to 15 micrometers. An overview of study findings will be presented including the inorganic composition of collected PM_{2.5}, concentrations of key trace gas species, and observations of wet deposition composition and fluxes. We will also examine variability in composition between sites, compare relative inputs from dry vs. wet deposition for various nitrogen species, and illustrate relationships between transport patterns and pollutant concentrations and deposition in the park.

^{*1}Corresponding author - Atmospheric Science Department, Colorado State University, Fort Collins, Colorado

²National Park Service/CIRA, Colorado State University, Fort Collins, Colorado



Simulating Deposition with a Regional Air Quality Model for the Rocky Mountain Atmospheric Nitrogen and Sulfur Study (ROMANS)

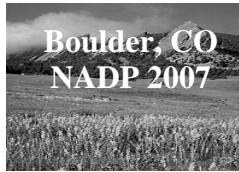
Michael G. Barna^{*1}, Marco A. Rodriguez², Kristi A. Gebhart¹,
Bret A. Schichtel¹ and William C. Malm³

Increased deposition to fragile ecosystems is anticipated as the population along Colorado's Front Range continues to grow. In particular, there is concern with regard to nitrogen deposition at high elevation ecosystems. The Rocky Mountain Atmospheric Nitrogen and Sulfur Study (ROMANS) are currently underway, and are designed to investigate the pollutant sources that are contributing to nitrogen deposition at Rocky Mountain National Park (RMNP). A regional-scale air quality, CAMx ("Community Air Quality Model with Extensions") is being used to simulate wet and dry deposition at RMNP during April and July, 2006. The model domain consists of a continental-scale 36 km domain, with nested 12 km and 4 km domains to address transport within the complex terrain of the Rocky Mountains. Wind fields and other meteorological inputs were provided by MM5 (Mesoscale Model, version 5), with available surface and sounder measurements incorporated into the observational data assimilation scheme. A detailed emission inventory, developed by the Western Regional Air Partnership for 2002, was updated for this study. In addition to the base emissions simulation, a series of conserved tracer simulations are being evaluated to bound the absolute contributions of numerous nitrogen sources within Colorado and beyond.

^{*1}Corresponding author - Air Resources Division, National Park Service, Fort Collins, CO 80524, Telephone: 970-490-8692; E-mail: barna@cira.colostate.edu

²CIRA, Colorado State University, Fort Collins, CO 80524

³National Park Service, CIRA/CSU, Fort Collins, CO 80523



Nitrogen Saturation in the Rocky Mountains: Linking Emissions, Deposition, and Ecosystem Effects using Stable Isotopes of Nitrogen Compounds

Donald H. Campbell^{*1}, Leora Nanus¹, JK Bohlke², Karen Harlin³, and Jeff Collett⁴

Elevated levels of atmospheric nitrogen (N) deposition are affecting terrestrial and aquatic ecosystems at high elevations in Rocky Mountain National Park and adjacent areas of the Front Range of Colorado. Federal and state agencies are now working together to develop cost-effective means for reducing atmospheric N deposition. To do this, there is a critical need for better understanding of N emission source areas and source types that contribute to N deposition in the Rocky Mountains Front Range of Colorado. In this study, isotopic signatures of N species in atmospheric deposition were related to source areas and source types of emissions such as energy generation, energy resource development, transportation, and agriculture.

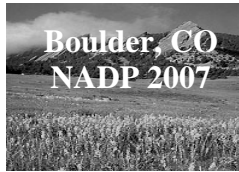
Snow, wetfall, and bulk precipitation samples were collected from sites on the eastern slope of the Continental Divide within the Park, and from a site approximately 150 km away on the western slope of the Colorado Rocky Mountains, where deposition rates are lower. There was a seasonal pattern with lighter $\delta^{15}\text{N}(\text{NO}_3)$ during the warmer months at all sites, which may indicate a shift in emissions types, or a change in atmospheric transport and transformations of nitrogen species. During the winter and spring months, the $\delta^{15}\text{N}$ values of nitrate in deposition at eastern slope sites were lower than those measured on the western slope, possibly because of greater influence of vehicle emissions and other sources of NO_x on the eastern slope. During summer, the west-east differences were not evident, but individual events indicated large differences in isotopic signature. These results indicate that incorporating local source characterization and finer spatial and temporal sampling into future studies could provide additional insight into nitrogen deposition source attribution.

^{*1}Corresponding author - U.S. Geological Survey, MS 415 Federal Center, Lakewood CO 80225
Telephone: 303-236-4882, ext. 298; E-mail: Donald.Campbell@usgs.gov

²U.S. Geological Survey, Reston, VA 20192

³National Atmospheric Deposition Program, Champaign, IL 61820

⁴Colorado State University, Ft. Collins, CO 80523



Spatial Distribution of Nitrogen Deposition in Rocky Mountain National Park

David Clow^{*1}, Mark Fenn², Don Campbell¹, Leora Nanus¹

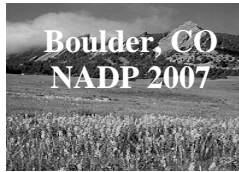
High-elevation streams and lakes in Rocky Mountain National Park are being adversely impacted by atmospheric deposition of nitrogen (N). Previous studies have documented high concentrations of nitrate in surface waters, particularly on the east side of park, and resultant changes in species composition of aquatic biota. Prevailing winds are from the west, but transport of pollutants from urban and agricultural sources to the east probably occurs during upslope meteorological conditions that are common during spring and summer. Higher N deposition rates on the east side of the park have been suggested as an explanation for the higher surface-water nitrate concentrations there, but there is little quantitative information about spatial patterns in N deposition in the park, largely due to the difficulty of access. Ninety-five percent of the park is managed as wilderness, which precludes motorized access.

In this study, a relatively new method using ion-exchange resin (IER) collectors is being tested as an inexpensive means of collecting spatially extensive deposition data in these wilderness settings. IER collectors use a 7 inch-diameter plastic funnel to capture rain, which flows downward through a column containing ion-exchange resin. Columns are swapped twice per year, and N compounds are eluted from the resins in the lab and analyzed. IER collectors were deployed in pairs from late July, 2006 to early October, 2006 along several east-west transects in the park. Valid samples were obtained from 11 sites on the eastern slope and 5 sites on the western slope. The median difference between pairs of co-located samplers was 13% for total N deposition, indicating good reproducibility. Nitrate deposition measured by IER collectors co-located with the Loch Vale NADP site matched that of the NADP collector (0.48 kg/ha); ammonium deposition was slightly higher from the IER collectors (0.60 kg/ha) than from the NADP collector (0.50 kg/ha). On average, ammonium accounted for $60 \pm 7\%$ of total N in the bulk deposition captured by the IER collectors, compared to 45% in wet deposition at the two NADP sites in the park. CASTNET data indicates that dry deposition of N occurs primarily as nitrate compounds, so the difference in ammonium deposition probably is not due to dry deposition. The IER collectors may be less prone to loss of ammonium via nitrification than NADP collectors.

Average N deposition for the 85-day exposure period at the eastern slope sites was 0.85 ± 0.21 kg/ha, and at west-slope sites was 0.69 ± 0.12 kg/ha. An ANOVA analysis indicated that differences in the means of east- and west-side sites were not statistically different at $p < 0.05$, however, these results should be interpreted with caution due to the small sample size. Sampling is continuing and additional sites have been added on the west side of the park to provide improved statistical power.

^{*1}Corresponding author - USGS, Denver Federal Center, MS 415, Denver Co, 80225
E-mails: dwclow@usgs.gov; dhcampbe@usgs.gov; lnanus@usgs.gov

²USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507
Email: mfenn@fs.fed.us



What is Causing the Recent Increases in NO₃ in Loch Vale Surface Waters?

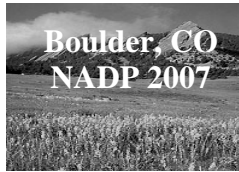
J.S. Baron*, T.R.Schmidt¹, and A. Krcmarik²

Nitrate concentrations at the outlet to Loch Vale watershed maintained average concentrations of ~1.0 mg/L from 1982 through 1998. In 1999 concentrations began to increase. Five-year running mean concentrations were nearly twice as high for the years centered around 2003 and 2004, and remain elevated above the 1982-1998 value. Annual precipitation has been at or below the long-term Loch Vale mean value of 102 cm/year since 1998, Mean annual temperatures appear to have increased since 1998, and N deposition is increasing at a rate of about 2% each year. None of these trends match the stream chemistry pattern, yet precipitation, temperature, and N deposition probably all contribute in some way. Since nitrogen is an essential and often limiting nutrient, biogeochemical processes may also be important to elucidating stream chemistry. We used structural equation modeling in an attempt to sort out the causal effects of climate, deposition, and ecosystem processes on stream chemistry. We found interactions among nearly all watershed components except lake algae, and no clear driver for the change in stream nitrate concentrations. It appears both precipitation and temperature influence forest soil processes that in turn influence stream chemical composition. Alpine soil processes were less connected to stream chemistry than forests. In addition to the direct influence of atmospheric nitrogen deposition, precipitation and temperature had strong, and different, direct influences on stream nitrate. Climate variability is therefore influencing watershed biogeochemistry in a way that complicates our efforts to track the effects of atmospheric nitrogen deposition trends in Loch Vale.

*Corresponding author - US Geological Survey, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins CO 80523-1499 Telephone: 970 491 1968; E-mail: jill@nrel.colostate.edu

¹US Geological Survey, Mineral Resources Team, Denver CO 80225, tschmidt@lamar.colostate.edu

²US Geological Survey, Fort Collins Science Center, Fort Collins CO 80526-8118

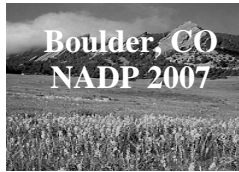


N Deposition Effects on Vegetation and Soils in Alpine Ecosystems

William D. Bowman
Mountain Research Station
Institute of Arctic and Alpine Research
University of Colorado, Boulder, CO 80309-0450

Alpine ecosystems provide important ecosystem and social services, including clean water and recreation. Alpine regions are subjected to elevated rates of N deposition relative to lowlands due to orographic enhancement of precipitation. Thin soils and strong seasonality and low rates of biological activity render alpine ecosystems very sensitive to ecological effects of deposition. Critical loads for compositional changes in vegetation, soils, and surface water determined empirically and by modeling range between 4 and 6 Kg N/ha/year in the southern Rocky Mountains, similar to mountains with granitic parent material in Europe. There is a strong potential for decreases in soil pH and extractable base cation concentrations, and increases in extractable Al^{3+} with sustained N deposition in alpine soils of the southern Rockies. Increases in plant production are small and transient with increasing N availability. Collectively these results indicate near simultaneous eutrophication and acidification in these alpine sites, with marginal biological buffering. In more heavily impacted alpine sites in the Western Tatra Mountains, Slovakia, increases in N deposition decreases plant growth, and results in decreases in soil extractable Al^{3+} , but gains in extractable Fe^{2+} . The Western Tatras appear to be in a transition stage from Al to Fe buffering of soils, and extreme N saturation causing inhibition of plant growth. Although significant reductions in acid precipitation have been achieved through control of S emissions, greater attention should be given to the strong potential for environmental impacts from N deposition, particularly in sensitive ecosystems such as the alpine.

*Corresponding author – Telephone: 303 492-2557; E-mail: william.bowman@colorado.edu



**Nitric Acid Dry Deposition at Conifer Forests:
Niwot Ridge, Colorado Subalpine Spruce-Fir Study**

H. Sievering^{*1,2,3}, C. Seibold¹, G. Rattray², and T. Tomaszewski³

The dry deposition velocity of nitric acid, $V_d(\text{HNO}_3)$, over a 13-m (mean ht.) spruce-fir forest at the 3000m asl NADP and AmeriFlux monitoring site of the Niwot Ridge Long Term Ecological Research (LTER) Program was estimated using the flux-gradient approach. Turbulence intensity at this site is high (mean u^* of 0.65 m s^{-1} with U of 2.9 m s^{-1}) and contributed to a large observed $V_d(\text{HNO}_3)$. However, the overriding contributor was found to be the small aerodynamic needle width of the site's conifer trees. Two flux-gradient measurement cases had inflated $V_d(\text{HNO}_3)$ due to height-differentiated HNO_3 loss to soil-derived particle surfaces. Not considering these cases, the mean $V_d(\text{HNO}_3)$ was 7.6 cm s^{-1} . The mean laminar boundary layer resistance (R_b) was found to be 7.8 cm s^{-1} (of slightly lesser magnitude than the aerodynamic resistance, 8.5 cm s^{-1}). The data-determined R_b is bracketed by two theoretical estimates of the mean R_b of 5.9 and 8.6 cm s^{-1} . These theoretical estimates include slightly differing considerations of the small canopy length scale (aerodynamic needle width) of $\leq 1 \text{ mm}$ at this subalpine spruce-fir forest (also some pine). The correlation of data-determined R_b values with both sets of theoretical estimates indicates that measurement error needs to be reduced and/or somewhat improved formulations of theoretical R_b values are in order. The most significant aspect of this HNO_3 dry deposition study at the Niwot Ridge LTER is that quite large $V_d(\text{HNO}_3)$ in the $3\text{-}10 \text{ cm s}^{-1}$ range were observed at a typical spruce-fir forest.

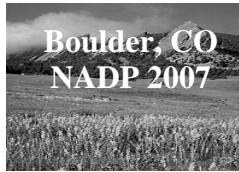
^{1*}Corresponding Author - Long Term Ecol. Res. Program of INSTAAR, Univ. of Colorado-Boulder, CO

² MS-Environ. Science Prog., Geog. & Environ. Sci. Dept., Univ. of Colorado-Denver

³ PhD in Environmental Studies Program, Univ. of Colorado-Boulder
INSTAAR, CB 206, 1560 30th St., Boulder, CO 80303

TECHNICAL SESSION: CRITICAL LOADS

Session Chair: Ellen Porter, National Park Service



Integrated Assessment Methods Used for Optimized Air Pollution Mitigation in Europe

Harald Sverdrup*, Jean Paul Hettelingh¹, Max Posch¹

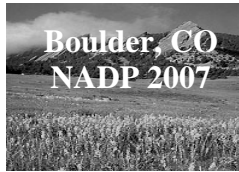
This presentation gives an overview of the United Nations Economic Committee for Europe, Long Range Transboundary Air Pollution (UN/ECE-LRTAP) Program, also commonly known as the European critical loads program, and we explain the methods and tools used in the UNECE integrated assessments. The authors go on to show examples of how the outputs from the National critical loads programs are used as inputs to the integrated assessments models, dealing with acidic deposition (sulfur and nitrogen, eutrophying deposition (nitrogen), ozone and interacting gaseous pollutants, and airborne particles. In the process, a number of parameters are used: The target functions are ecosystem protection and human health protection, expressed as % of area affected above threshold and impacts on life expectancy and accumulated days of hospitalization. Other important parameters are cost effectiveness of measures, fair distribution among nations and synergies with ongoing industrial transitions and restructuring processes. Important tools in this process are the EMEP, RAINS, and GAINES models, as well as the coordinating work performed by the Dutch Ministry for health and environment (RIVM) and the International Institute for Systems Analysis (IIASA) at Laxenburg in Austria. These models are used in a soft-linked system to look for optimal emissions, physical effects and economic benefits. The complex scientific process by which the information is ultimately used to set emissions reductions goals and distribute them amongst the regions and nations of Europe is outlined.

The authors conclude that the process in Europe was one of great benefit to the participating nations, by preventing damaging pollution impacts, maximizing benefit and minimizing cost. By use of an adaptive managerial model for the effort, the process was adapted to increase environmental and public demands as well as it proved to be cost-efficient and politically supported by all participants. With the mitigation of air pollution in Europe, the experiences of RAINS in Asia, and the rise of air pollution as a global problem, the authors suggest that continuing the process to other continents would be beneficial for pollution mitigation.

*Corresponding author – Professor of Chemical Engineering, Lund University, Lund, Sweden

¹Director of the Coordination Centre for Effects, National Environmental Assessment Centre, Bilthoven, Netherlands

¹Senior Scientist at the Coordination Centre for Effects, National Environmental Assessment Centre, Bilthoven, Netherlands



Recent Developments in Determining Critical Loads for Sulphur and Nitrogen Deposition in Western Canada

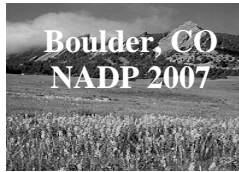
Silvina Carou^{*}, Julian Aherne¹, Shaun Watmough¹, Dean Jeffries²

In Canada, the critical load approach has been adopted to assess where and by how much sulphur dioxide (SO₂) and nitrogen oxide emissions need to be reduced in order to protect sensitive ecosystems from acid deposition damage. National acid rain assessments produced in the last 15 years have presented critical load information for eastern Canada. Estimates for this part of the country have evolved significantly from critical loads of wet sulphate deposition for all but the most sensitive lakes, to more refined and comprehensive estimates of total (wet plus dry) acid deposition (sulphur plus nitrogen) for lakes and forest soils combined. This information is also essential to track the implementation of domestic programs such as the Canada-wide Acid Rain Strategy for Post 2000 (The Strategy), which commits eastern provinces to reducing SO₂ emissions in order to meet the long term goal of reducing acid deposition below critical loads. The Strategy also commits provinces and territories to “keep clean areas clean”. Although eastern Canada continues to be the largest area susceptible to continued acid rain damage, comparatively little information is available for western Canada and, as a result, deposition and ecosystem sensitivity are poorly understood. In an effort to assess the potential for acidification problems in western Canada, first cut estimates of the region’s critical loads and critical load exceedances are being completed for soils and surface waters. Critical load estimates available for forest soils in Saskatchewan (SK) and Manitoba (MB) show that approximately 2% of mapped soils in SK and 7% in MB receive damaging levels of sulphur and nitrogen deposition. Forest soils in Alberta (AB) and British Columbia (BC) are also being assessed. Some areas of AB and BC are characterized by alpine ecosystems but very limited deposition and ecosystem data are available at this time to properly assess their sensitivity. However, preliminary estimates of critical loads of nutrient nitrogen for alpine ecosystems in southern BC indicate they may be exceeded due to high levels of nitrogen deposition. In terms of aquatic critical loads of acid deposition, new estimates are available for Manitoba that span a broader range than previously available. Future plans include assessing the critical loads of total acid deposition over all of Canada for lakes and forest soils combined. The results will be used to evaluate the success of, and future needs for, emission reduction commitments under The Strategy.

^{*}Corresponding Author - Atmospheric Science Assessment and Integration, Environment Canada, 4905 Dufferin St., Toronto, Ontario, Canada M3H 5T4, Telephone: 416-739-4879; E-mail: silvina.carou@ec.gc.ca

¹ Environmental and Resource Studies, Trent University, Peterborough, ON, Canada K9J 7B8

² Aquatic Ecosystem Impacts Research Division, Environment Canada, Burlington, ON, Canada L74 4A6

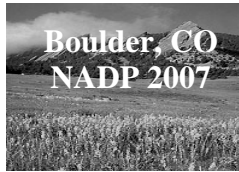


Overview of Recent Critical Load Efforts in the U.S.

Richard Haeuber
US EPA
Clean Air Markets Division (6204J)
Ariel Rios Building
1200 Pennsylvania Ave., N.W., Washington, D.C. 20460

Critical loads may be a promising approach to assess implementation of current air quality programs in the U.S. and inform development of future policies and programs to protect ecosystems from air pollution impacts. Development of critical loads is at an early stage in the U.S., with a relatively small number of critical loads efforts, generally at site-specific scales. While site specific critical loads are useful in assessing ecosystem conditions, a number of technical issues must be addressed before a critical loads approach in the U.S. context can be developed for broader regional scales. These issues include ecological indicators and threshold values, critical loads models, data availability, environmental monitoring, and communicating data and results in a policy and management context. Various national and regional scale critical loads projects and activities are currently underway throughout the U.S. This talk provides an overview of recent critical loads projects and their potential for helping to address technical aspects of critical loads development and implementation in the U.S.

*Corresponding author – Telephone: 202-343-9250; Fax: 202-343-2360;
E-mail: haeuber.richard@epa.gov



A Multi-Agency Critical Loads Development and Implementation Process for the Northeast U.S.

Gary Kleiman
Science and Technology Program Manager
NESCAUM/NESCCAF
101 Merrimac Street, 10th Floor
Boston, MA 02114

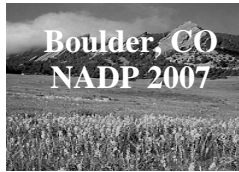
The Northeast U.S. has been challenged by acid deposition for more than 40 years. Given the geologic, ecosystem, and land-use diversity of the region, management approaches based upon critical loads are well suited for application in the Northeast. The development and implementation of a successful management framework, however, will depend upon multi-agency support for a scientific approach for establishing critical loads across the region. A pilot initiative is being undertaken by 11 Eastern States, The U.S. EPA, U.S. Forest Service, U.S. Geologic Survey, and the U.S. National Park Service to develop a scientific foundation for determining critical loads for both terrestrial and aquatic ecosystems utilizing steady-state and dynamic modeling approaches on a regional basis.

This talk will review the development of critical loads in New England through the New England Governors/Eastern Canadian Premieres Acid Rain Steering Committee and briefly discuss how these products are informing policy decisions in the region. For example, New Hampshire's Fish and Game Department has used the critical loads maps to survey forests at risk for their statewide assessment of 'habitats at risk' and Canadian officials have used the critical loads estimates in assessing the sensitivity of ecosystems to deposition for the PM Annex to the Canada-U.S. Air Quality Agreement.

In addition, the Northeast States' perspective on acid deposition issues and the need for additional ecosystem protection will be presented as context for why various management approaches based upon critical loads are now being considered. With the advent of market based approaches under the Title IV Acid Rain Program, the Eastern U.S. saw broad reductions which have resulted in substantial signs of recovery in up to one-third of acidified Northeast Lakes and Streams [U.S. EPA, 2003]. Unfortunately, this means that we have seen a lack of substantial recovery in over two-thirds of acidified surface waters to date. Future management approaches based on critical loads may provide resource managers with options that would enable them to address individual ecosystems by identifying the specific stresses that are affecting each unique system. Existing air quality programs such as the Regional Haze program may provide useful analogs for using physically-based environmental targets (e.g. natural visibility conditions versus critical loads) as a basis for setting program goals.

Finally the presentation will review the multi-agency process for developing a scientific basis for establishing regional critical loads and the important role that state agencies and the federal partners will play in establishing regional critical loads protocols in the Eastern U.S. This process will include the formation of a stakeholder working group representing state air agencies and other environmental management agencies as needed and multi-agency federal partners. The focus of this pilot will be on identifying approaches that are easy to calculate with regional consistency, have credibility based on current knowledge, and are flexible enough to allow for changes as our scientific understanding improves. The process will include an initial meeting to explain the technical approach and achieve buy-in to the process followed by a series of quarterly calls and meetings to detail progress, explain decision-points and achieve group consensus on a path forward.

*Corresponding author - Telephone: 617-259-2027



Integrating a Critical Load for Rocky Mountain National Park into the State of Colorado's Planning Process

Mike Silverstein

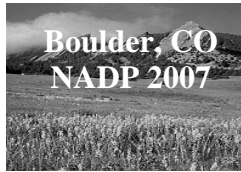
Colorado Department of Public Health and Environment Air Pollution Control Division
4300 Cherry Creek Drive South, Denver CO 80246-1530

The Colorado Department of Public Health and Environment has been working collaboratively with the National Park Service, EPA Region 8 and numerous stakeholders to address the deleterious impacts of nitrogen deposition in Rocky Mountain National Park. As a result, a plan to reduce nitrogen deposition has been developed and endorsed by the three agencies and will be implemented to achieve resource management goals over a 25 year period. The presentation will summarize the plan and the action measures and provide an overview of how sound science was incorporated into the administrative process.

*Corresponding author – Telephone: 303-692-3113; E-mail: mike.silverstein@state.co.us

TECHNICAL SESSION: TOTAL MERCURY DEPOSITION

***Session Chairs: Eric Prestbo, Tekran Corporation &
David Gay, Illinois State Water Survey***



Mercury Dry Deposition Almost 2 Decades Later: Musings of an O.F.

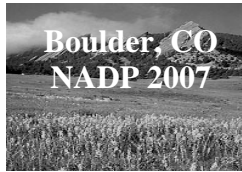
Steve Lindberg* and Daniel Obrist¹

At the inaugural ICMGP (International Conference on Mercury as a Global Pollutant) around 1989, a paper was presented titled “The Dry Deposition of Mercury.” Unfortunately, the audience was small, but was polite enough to make little noise when they exited en masse mumbling “what the heck is he talking about?” Also unfortunately, that paper was mine (perhaps it was my graphics, see Fig. 1 below). Both we, and the science, have come a long way since then, but do we yet understand the role of dry deposition? I fondly recall the struggles involved with our original NADP Mercury Deposition Initiative back in 1994. And now, somewhat to my amazement and much to my delight, the MDN continues to set records for longevity and breadth as it enters its second decade. Last year the NADP proposed expansion of the original initiative to include dry deposition.

In the ensuing decade(s), sufficient progress has been made to at least suggest the importance of dry deposition, though precious few actual measurements exist. As might be expected, most all of the methodology developed during the acid rain era for S & N has been applied to Hg in some fashion. On one hand, dry deposition has been estimated from leaf-washing experiments (with little assurance that dry deposited Hg can be effectively washed from leaves), from various gas exchange chambers (does only gaseous Hg matter?), from the ecosystem fluxes throughfall and litterfall (what about complications from soil uptake and foliar leaching?), and data exist for deposition to surrogate surfaces (of exactly what one wonders?). On the other hand, a few estimates have been derived from micrometeorological measurements (including concentration gradients, modified Bowen ratio, and relaxed eddy accumulation). Of course (and I say this fondly), there are any number of model estimates (“caution, you are entering a data-free zone”). In these musings I’ll attempt to explore what we do, what we don’t, and what we only think we know about Hg dry deposition, and why that matters.

*Corresponding author – ERC (enjoying retirement completely), PO Box 1895, Graeagle, CA 96103 Telephone: 530-836-2320; E-mail: Lindberg@Now2000.com

¹Desert Research Institute, Division of Atmospheric Sciences, 2215 Raggio Parkway, Reno, NV 89512



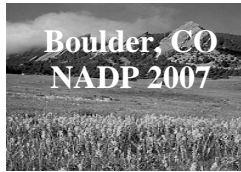
Wet and Dry Deposition of Atmospheric Hg at Three Sites Across the Southeastern U.S.

Eric S. Edgerton
ARA, Inc.,
410 Midenhall Way, Cary, NC, 27513

Atmospheric Hg inventories show that anthropogenic sources are important on local, regional and global scales. As important as the magnitude of emissions is their chemical form. Elemental Hg has a long atmospheric lifetime (months) and is therefore broadly dispersed from the point of emission. Reactive gaseous Hg (RGM) and particulate mercury (Hg_P), in contrast, are removed from the atmosphere much more quickly (days-weeks) and thus have more local to regional ranges of influence than elemental Hg. Long-term measurements of all three forms of Hg therefore are needed to understand the sources, transformations, impact of mitigation strategies and spatial distribution of atmospheric Hg. This presentation will: 1) describe measurement and data reduction protocols for atmospheric Hg; and 2) analyze 3 years of speciated Hg data from 3 sites across the southeastern U.S.; and 3) compare measured wet deposition rates with inferred dry deposition rates. Elemental Hg (Hg^0), reactive gaseous Hg (RGM) and fine particulate Hg (Hg_P) measurements are made at the three sites on an hourly time base using a Tekran 2537A, equipped with 1130 and 1135 speciation modules. The three sites are Yorkville, GA, a rural site 65 km NNW of Atlanta; OLF, FL, a suburban site 15 km NW of Pensacola, and BHM, AL an urban-industrial site in Birmingham. Analyzers are calibrated with Hg^0 using an internal permeation device and checked for transmission efficiency by method of addition immediately upstream of the RGM denuder. Additional quality assurance includes comparison with manual samples and desorption of RGM-spiked denuders. Wet deposition is also measured according to Mercury Deposition Network (MDN) protocols and dry deposition is calculated for each species using resistance analogies. Ancillary measurements at both sites include, SO_2 , NO_y , CO and surface meteorology.

Results show striking differences across sites. At the rural site, average Hg^0 , RGM and Hg_P concentrations are 1590 pg/m^3 , 2.7 pg/m^3 and 1.2 pg/m^3 , respectively, while at the urban industrial site average Hg^0 , RGM and Hg_P concentrations are 2485 pg/m^3 , 55.7 pg/m^3 and 10.3 pg/m^3 , respectively. Maximum concentrations of Hg^0 and RGM at the urban-industrial site exceed $30,000 \text{ pg/m}^3$ and 8500 pg/m^3 , respectively, indicating significant local sources, some of which have characteristic signatures of SO_2 , CO and NO_y . All sites exhibit weak, but statistically significant, diurnal patterns for Hg^0 , strong diurnal patterns for RGM and no diurnal pattern for Hg_P . Limited measurements at the suburban site (20 km from the Gulf of Mexico) suggest there is several times more Hg_P above $2.5 \text{ }\mu\text{m}$ aerodynamic diameter than below. Given that the "standard" Tekran configuration uses a $2.5 \text{ }\mu\text{m}$ cutpoint inlet, this observation suggests that Hg_P concentrations and dry deposition rates are significantly underestimated. Measured wet deposition and calculated dry deposition are factors of about 1.5 and 4 higher at the urban-industrial site than the rural site; however, dry deposition estimates are very sensitive to assumptions regarding transfer rates for Hg^0 and RGM. Further work is needed to address overall uncertainties in dry deposition calculations.

*Corresponding author – Telephone: 919.522.8565; E-mail: ericedge@gte.net



Atmospheric Mercury Measurements in the Gulf of Mexico and Mid-Atlantic Regions: Early Results from an Emerging Monitoring Network

Winston Luke^{*1}, Mark Cohen¹, Paul Kelley¹, Steve Brooks², Jake Walker³

The presence of mercury in the environment, its wide distribution and cycling in coastal and aquatic ecosystems, and risks to human health constitute a major environmental resource management issue. The majority of mercury emitted to the environment is injected into the atmosphere through the combustion of fossil fuels, incineration of mercury-containing waste, and metallurgical processes (e.g., smelting). Wet and dry atmospheric deposition delivers mercury to sensitive aquatic ecosystems, where it can be converted to more toxic and bio-available forms such as methylmercury. Human exposure to methylmercury, which adversely affects the nervous system, results from consumption of contaminated fish and other organisms in the aquatic food web.

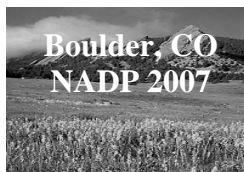
Despite mercury's importance, however, many of the complex processes controlling its movement through the environment are poorly understood, and there is debate over the efficacy of emission controls in reducing mercury concentrations in estuarine and marine fish. In 2006 the National Atmospheric Deposition Program (NADP) introduced the Atmospheric Mercury Initiative to address many of these uncertainties. The initiative seeks to establish a network of sites to "...measure event-based mercury wet deposition, air concentrations of mercury in its gaseous and particulate forms, and meteorological and land-cover variables needed for estimating dry deposition fluxes [NADP, 2006]."

We present early results from two such sites in the emerging network: a rural site at the Grand Bay National Estuarine Research Reserve (NERR) in Moss Point, MS, and a suburban site on the campus of the Beltsville Agricultural Research Center (BARC) in Beltsville, MD. The measured atmospheric mercury concentrations at the sites (elemental Hg(0), reactive gaseous mercury, and fine particulate mercury) will be summarized, and will be interpreted using ancillary measurements of primary (CO, NO/NO_y, SO₂) and secondary (O₃) trace gases at each site; prevailing meteorology; and back trajectory analysis. Results of quality assurance exercises, designed to estimate the precision of co-located mercury measurements and to better characterize instrument response variations under a variety of conditions, will also be discussed.

^{*1}Corresponding author - NOAA/Air Resources Laboratory (R/ARL), SSMC3, Rm. 3316, 1315 East West Hwy., Silver Spring, MD 20910 Telephone: 301-713-0295; E-mail: Winston.Luke@noaa.gov, Mark.Cohen@noaa.gov, Paul.Kelley@noaa.gov

²Canaan Valley Institute, P.O. Box 673, Davis, WV 26260 Telephone: 304-463-4739; E-mail Steve.Brooks@noaa.gov

³Grand Bay National Estuarine Research Reserve, 6005 Bayou Heron Rd., Moss Point, MS 39562 Telephone: 228-475-7047; E-mail: Jake.Walker@dmr.ms.gov

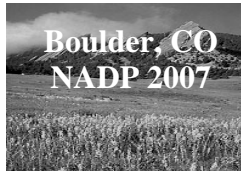


Trends and Modeling of the Total Gaseous Mercury Flux and Mercury Deposition in the Leaf Litter Fall in a Northeastern Red Maple Canopy

Jesse O. Bash
NOAA Atmospheric Research Laboratory
U.S. EPA National Exposure Research Laboratory
MD-E243-04, Research Triangle Park, NC 27711

Net total gaseous mercury (TGM) exchange, mercury deposition in the leaf litter fall, and wet deposition fluxes were measured from the spring of 2004 through the summer of 2005 along with mercury concentrations in the atmosphere, soil, vegetation, and precipitation at sampling locations in and around a hardwood forest. TGM exchange over a closed red maple (*Acer Rubrum*) canopy and the litter fall flux were measured for the 2004 and second half of the 2005 growing seasons at the University of Connecticut's research farm in Coventry, Connecticut. The wet deposition flux was measured at an uncultivated field site three miles from the forest experiment site. Seasonal trends were measured in the wet deposition volume weighted concentrations and in the direction and magnitude of the TGM flux. Net TGM evasion was dominant during the early spring and late summer. TGM concentrations in the wet deposition peaked in late spring and early summer. During the growing season there was a significant trend from net deposition after leaf out to net evasion in the late summer through the fall senescence. Evasion was dominant during periods when the canopy was wet from either dew or rainfall which was about 50% of the total time. Atmosphere – forest canopy compensation points in the TGM flux were measured in the range of background concentrations. Over the duration of the experiment the mean annual wet deposition was $6.57 \mu\text{g m}^{-2}$, the leaf litter deposition was $12.10 \mu\text{g m}^{-2}$, and the net canopy flux during the growing season was an evasion of $12.94 \mu\text{g m}^{-2}$. Mercury was found to accumulate in the organic matter of the soil and in vegetation foliage. The relationships between the foliar concentrations of mercury, the atmosphere-vegetation compensation point, and cycling of mercury in this forest stand are being investigated through the use of the EPA's community multiscale air quality (CMAQ) model.

*Corresponding author - Telephone: 919-541-0862; Fax: 919-541-1379
E-mail: jesse.bash@noaa.gov bash.jesse@epa.gov



Strategies to Assess Mercury Impacts and Minimize Their Effects in Colorado and Beyond

Mark McMillan* and Koren Nydick¹

Mercury is the most frequently listed substance for fish consumption advisories in the United States. In Colorado, at least sixteen (16) water bodies have these advisories, often thought to be due in part to atmospheric deposition of mercury. Mercury concentrations in sport fish from several Colorado reservoirs have exceeded the 0.5 microg/g action level, resulting in mercury fish consumption advisories for McPhee, Narraguinnep, Navajo, Sanchez and Vallecito Reservoirs. Sediment core analysis for Narraguinnep Reservoir show that mercury fluxes increased by approximately a factor of two after about 1970. Total mercury in wet deposition has been monitored at Mesa Verde National Park since 2002 as part of the Mercury Deposition Network (MDN). Results show mercury concentrations among the highest in the nation. Mercury concentrations have also been measured in snowpack at a few sites in the San Juan Mountains by the USGS and moderate concentrations similar to the Colorado Front Range have been recorded.

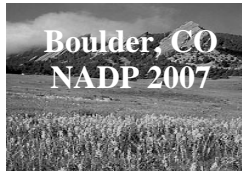
Due to national concerns over mercury pollution, environmental and public health agencies are being asked to investigate mercury pollution and associated pollution reduction activities. To address these concerns and issues in Colorado, in 2000 the Colorado Department of Public Health and Environment (CDPHE) began investigating aggressive and holistic options for reducing mercury pollution. This cross media program, the "Mercury-Free Colorado Campaign," is designed to reduce the emissions of and impacts from mercury pollution. From this vision, CDPHE developed and implemented six primary areas of focus including: a nationally-recognized automotive switch removal initiative, a crematoria/Best Management Practices program, a dental amalgam effort, a consumer outreach endeavor for thermometers and thermostats, a problem characterization exercise to identify the issues, and an education and outreach campaign to increase the public's understanding of this issue.

This mostly policy focused presentation will provide attendees with information regarding efforts the State of Colorado and our partners have taken to better characterize mercury impacts and steps to minimize the emissions of and impacts from mercury. Such efforts include local interest in expanding mercury deposition monitoring (wet and dry) and developing a comprehensive mercury source apportionment study to investigate the impact of local and regional coal combustion sources on atmospheric mercury deposition. In addition, environmental metrics to gauge and direct the success of the mercury program will be shared.

*Corresponding author - M.S., Manager, Mercury Program, Colorado Department of Public Health and Environment, Denver, Colorado Telephone: 303-692-3140;

Email: mark.mcmillan@state.co.us

¹Ph.D., Director of Research & Education, Mountain Studies Institute, Durango, Colorado



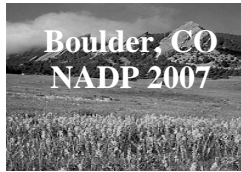
Atmosphere-Land Dynamics of Mercury in a Forest Landscape of the Adirondack Region of New York.

Charles T. Driscoll^{*1}, Joseph T. Bushey¹, Alexei G. Nallana¹, Pranesh Selvendiran¹,
Hyun-Deok Choi² and Thomas M. Holsen²

Atmosphere-land dynamics of mercury were investigated at the Huntington Forest in the central Adirondack region of New York. Measurements of mercury were made in air, wet deposition, throughfall, foliage, litter, and streamwater, and soil mercury evasion was characterized. Measurements show a slight enrichment of mercury in throughfall ($6.83 \mu\text{g}/\text{m}^2\text{-yr}$) compared to wet deposition ($5.79 \mu\text{g}/\text{m}^2\text{-yr}$) in this northern hardwood watershed. Large increases in concentrations of mercury were evident in foliage of the dominant hardwoods over the growing season, with accumulation of mercury in American beech significantly higher than in sugar maple or yellow birch. Concentrations of mercury in understory foliage were significantly greater than overstory foliage. Concentrations of mercury in hardwood litter were consistent with values observed in foliage. Litter flux of mercury ($17.2 \mu\text{g}/\text{m}^2\text{-yr}$) greatly exceeded throughfall and was the major pathway of mercury deposited to the forest floor ($24.0 \mu\text{g}/\text{m}^2\text{-yr}$). Soil evasion of mercury was highly variable across diurnal cycles and the annual cycle, and was highly dependent on environmental conditions (e.g., temperature, radiation). Our best estimate of mercury evasion from upland soil ($10.4 \mu\text{g}/\text{m}^2\text{-yr}$) suggests that this flux exceeded throughfall, but is less than total mercury deposition. Stream fluxes ($2.3 \mu\text{g}/\text{m}^2\text{-yr}$) indicated that most of the mercury deposited to the watershed is evaded back to the atmosphere or retained in soil. However, stream losses are a critical pathway of mercury supply to aquatic ecosystems and ultimately human and wildlife exposure. Stream mercury species flux increased greatly during storm events, driven by the increase in runoff. Source areas of mercury varied within events, with recently deposited mercury readily mobilized on the rising limb of the hydrograph before shifting to mercury derived from soil water as the hydrograph peaked. The form and source of mercury may have important implications for the bioavailability in downstream Arbutus Lake.

^{*1}Corresponding Author – Department of Civil and Environmental Engineering, Syracuse University, Syracuse, NY 13244 Telephone: 315-443-3434; E-mail: ctdrisco@syr.edu

²Department of Civil and Environmental Engineering, Clarkson University, Postdam, NY 13676



Development of Surrogate Surfaces for Assessing Dry Deposition of Atmospheric Hg

Seth Lyman¹, Mae Gustin*¹, Eric Prestbo², Phil Kilner³

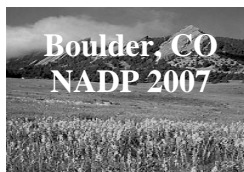
Dry deposition is thought to be an important pathway for input of mercury to aquatic and terrestrial environments, but methods to measure mercury dry deposition flux are not well established. Polysulfone cation-exchange membranes are being developed as surrogate surfaces to estimate dry deposition of reactive gaseous mercury (RGM). In a preliminary study, accumulation of mercury on membranes was well correlated with air RGM concentrations ($r = 0.93$, $p < 0.001$) and with modeled RGM deposition ($r = 0.97$, $p < 0.001$), though deposition to membranes was about five times greater than modeled RGM deposition. Field experiments are being done in Reno, Nevada, USA to characterize uptake rates of ambient RGM under differing environmental conditions. Laboratory experiments are being done to characterize gaseous elemental mercury and RGM uptake by the membranes as a function of atmospheric concentrations as well as different temperature, humidity, light and atmospheric chemistry exposures. These will help us establish uptake rates as a function of exposure concentrations that can then be compared to field data and modeled deposition values. We have also begun deployment of the membranes at other field sites where air speciation and a variety of other environmental parameters are being measured in the United States. These data will allow us to assess membrane behavior in different environmental conditions. Additionally, optimal handling and deployment procedures are being developed, and the cation-exchange membranes are being compared against other surfaces for efficiency of RGM uptake.

*¹Corresponding Author – Telephone - 775-784-4203; E-mail: mgustin@cabnr.unr.edu

¹University of Nevada, Reno / MS370, Department of Natural Resources and Environmental Science Reno, Nevada 89557

²Tekran Instrument Corporation, 330 Nantucket Blvd., Toronto, ON M1P2P4

³Frontier Geosciences, 414 Pontius Avenue North, Seattle, Washington 98109



Plume-in-Grid Modeling of the Atmospheric Deposition of Mercury over the United States

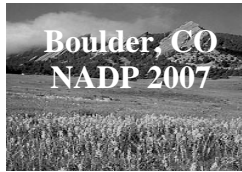
Krish Vijayaraghavan*¹, Prakash Karamchandani¹, Rochelle Balmori¹, Christian Seigneur¹,
Leonard Levin², John J. Jansen³

CMAQ-MADRID-APT (the Community Multiscale Air Quality model coupled with new particulate matter (PM) and mercury modules and advanced plume treatment) is a multi-pollutant model which offers sophisticated treatments of ozone, PM and mercury processes. The model has been further enhanced with a state-of-the-science analysis of the atmospheric dynamics and chemistry of mercury in plumes from elevated point sources. This paper presents the application of this plume-in-grid model to simulate the wet and dry deposition of mercury species over the United States during 2001. Meteorology is driven by the Mesoscale Model version 5 (MM5). Emissions of criteria pollutants and mercury over the United States were obtained from the U.S. EPA and are based on the National Emission Inventory (NEI) for 1999 with additional corrections made by EPA for MACT controls of mercury emissions from some waste incinerators. CMAQ-MADRID-APT is applied here over a domain that covers the continental United States and parts of Canada and Mexico and has a horizontal resolution of 36 km with 14 vertical levels extending up to the tropopause. Model performance is evaluated by comparison of simulated wet deposition of mercury with 2001 wet deposition data from the Mercury Deposition Network (MDN) in the National Atmospheric Deposition Program (NADP). The impact of using an explicit treatment of the plumes from thirty large coal-fired power plants in the United States on local and regional mercury deposition is investigated.

*¹Corresponding Author - Atmospheric & Environmental Research, Inc. (AER), 2682 Bishop Drive, Suite 120, San Ramon, CA 94583 Telephone: 925-244-7127; Email: krish@aer.com

²EPRI, 3412 Hillview Avenue, Palo Alto, CA 94304

³Southern Company Services, P.O. Box 2641, Birmingham, AL 35291



Understanding Relationships Between Mercury Concentrations and Certain Water Quality Characteristics: Biogeochemical Cycling of Mercury and Methyl Mercury in Great Smoky Mountains National Park

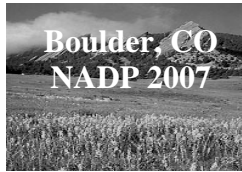
Suzanne Fisher
Tennessee Valley Authority
400 W. Summit Hill Dr., Knoxville, TN 37902

Weekly sampling of total mercury in wet deposition has been underway at Clingmans Dome in Great Smoky Mountains National Park since 2002 as part of the Mercury Deposition Network (MDN, TN-12). While concentrations of mercury from the Clingmans Dome site have seasonally (May-October) averaged 9.10 ng/L in precipitation, yearly rainfall amounts for this high-elevation ecosystem are over 86 inches. Monitoring results indicate that mercury concentrations in Great Smoky Mountains National Park are similar to most MDN sites throughout the U.S., and mercury deposition is similar to other monitoring sites located in the southeastern U.S., albeit higher than Northeastern and Midwestern states. Wet deposition alone, however, does not represent the total amount of mercury deposited to the ecosystem. Both dry deposition (particles or gases that are deposited onto foliage and the landscape) and cloud deposition (cloud or fog droplets containing pollutants enshrouding vegetation or other surfaces) of mercury also contribute to the total atmospheric deposition the ecosystem receives. These two forms of deposition are not currently being measured in Great Smoky Mountains constituting a gap in data relevant to the atmospheric deposition of mercury.

Once atmospheric mercury is deposited onto the land and surface waters, complex changes and cycling throughout the ecosystem occur. The fate and mobility of atmospherically deposited mercury to terrestrial environments is poorly understood. Preliminary results from the METAALICUS study suggest that terrestrial systems impose a time lag for the delivery of atmospheric deposition to lakes via runoff. The presence of organic matter in soils influences watershed mercury cycling, as mercury has been shown to form strong complexes with organic matter. Several studies have demonstrated foliar exchange of gaseous elemental mercury through leaf stomata and subsequent loading to the forest floor via litterfall. Studies have also shown upland soils to be a sink for methyl mercury and that in streams draining high-elevation forest ecosystems, particularly with high dissolved organic carbon content, methyl mercury production could occur.

I will discuss the mid-season results of measurements collected from a high-elevation catchment taken at two elevations (2,025 and 1,800 m) in Great Smoky Mountains National Park. Measurements are being taken to determine 1) the relative input of total and methyl mercury concentrations in throughfall, leaf litter, and soils in conjunction with current wet deposition sampled by the Mercury Deposition Network, 2) concentrations of total and methyl mercury and the proportion of mercury in dissolved versus particulate phases of stream water, 3) measurements of watershed components such as sulfate, dissolved organic carbon, and redox potential that influence mercury distribution and cycling in terrestrial-aquatic interface, and 4) the impact of seasonal snow melt and storm events on discharge of total and methyl mercury in the watershed.

Corresponding Author - Telephone: 865-632-6935; E-mail: lsfisher@tva.gov



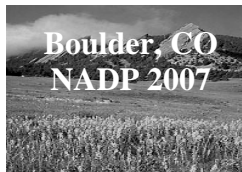
Mercury Mass Balance in Decomposing Leaf Litter

Kathleen Knight and Dr. David R. Miller
University of Connecticut
Natural Resources Department

Tree leaves accumulate large amounts of mercury (Hg), during each growing season from the atmosphere. Leaf senescence is a significant transfer of atmospheric mercury to the soil surface. Nonetheless, little is known about the disposition of the mercury in decomposing litter. This study was designed to determine the Hg transport and storage pathways in the decomposition process. Composting the litter allowed us to control the decomposition rate and monitor the Hg budget of the compost during the various stages of decomposition. Two compost piles of tree leaf litter were observed, to reveal the movement and chemical transformations mercury goes through during the leaf degradation process. One of the piles was turned manually while the other remained static to provide two different aeration conditions.

Measurements of the Hg inputs (wet and dry deposition), the Hg outputs (leaching and evasion to the atmosphere) and the Hg storage in the pile were made over a 6 month composting season. The measurements demonstrated that only a small amount of the Hg originally in the leaves was leached into the soil. The loss to the atmosphere through gaseous evasion was insignificant. Leaf decomposition released less than one percent of the total Hg in the leaf material. Thus, over 99% of the initial Hg in the leaves remained tightly held to the organic matter during decomposition.

POSTER SESSION
(IN ALPHABETICAL ORDER BY FIRST AUTHOR)



**Trends in Cloud Water Sulfate and Nitrate as Measured at Two
Mountain Sites in the Eastern United States:
Regional Contributions and Temporal Changes Compared with
Regional Changes in Emissions, 1986-1999**

James B. Anderson*, Ralph E. Baumgardner, Jr.¹, and Sandra E. Grenville²

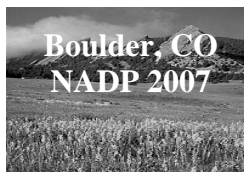
Air pollutant emissions in the US generally peaked in 1970, the year that the Clean Air Act was passed, and have declined since, except for oxides of nitrogen (NO_x), which have remained steady or slowly increased. In 1995 Phase 1 of the Clean Air Act Amendments (CAAA) of 1990 went into effect resulting in a sharp drop in sulfur dioxide (SO₂) emissions in most areas. Pollutant concentrations measured in precipitation and ambient air generally reflected the changes in emissions in most areas of the eastern US. Only the southern Appalachian Mountain region did not see an appreciable improvement in precipitation acidity over the last decade.

Previous studies of cloud chemistry in the eastern US found no pattern of temporal trends, possibly because of large year-to-year variation in meteorology. In this paper, we present spatial and temporal trends in SO₄²⁻ and NO₃⁻ concentrations of cloud water samples collected in warm seasons only at two mountain sites (Whiteface Mountain, NY and Whitetop Mountain, VA). This analysis is based on a combined cloud chemistry data-set collected by EPA's Mountain Cloud Chemistry Program (MCCP) (1986–1989) and Mountain Acid Deposition Program (MADPro) (1994–1999). Sample concentrations were (1) normalized by liquid water content (to reduce within-cloud variation) and (2) segregated into 901 arrival quadrants based on 36 h back trajectory analysis (to diminish between-cloud or meteorological variation). For each quadrant at the two sites, annual (12 month) county emissions of SO₂ and NO_x were compiled out to 600, 1000, and 1600 km, and these values were compared with the annual means (warm season only) of normalized SO₄²⁻ and NO₃⁻ concentrations in hourly samples of cloud water (segregated by back-trajectory) collected at each site. For the period 1987–1999, Quadrant 3 (SW) for Whiteface Mt. and Quadrants 3 (SW) and 4 (NW) for Whitetop Mt. had the highest SO₂ emissions and showed the largest decline in SO₂ emissions after the CAAA was implemented. These same quadrants which had the largest decrease in emissions showed significant declines in cloud water SO₄²⁻ over the time period. NO_x emissions were highest in Quadrant 3 for Whiteface Mt. and in Quadrants 1 and 4 for Whitetop Mt. Only in Quadrant 1 at Whitetop Mt. did NO_x emissions decrease during the study period (1987–1999). Cloud water NO₃⁻ showed no consistent pattern at either mountain site with some quadrants having higher cloud water NO₃⁻ values after Phase 1 of the CAAA and other quadrants having little change in cloud water NO₃⁻ values.

*Corresponding author - Center for Wetlands and Water Resources, The University of Mississippi Field Station, 15 Road 2078, Abbeville, MS. 38601 Telephone: 662-915-5804;
E-mail: jandersn@olemiss.edu

¹National Exposure Research Laboratory, US Environmental Protection Agency, Research Triangle Park, NC 27709 Telephone: 919-541-4625; E-mail: Baumgardner.Ralph@EPAmail.EPA.Gov

²Air Quality Services, Inc., 1604 Brookwood Road, Jacksonville, FL 32207
Telephone: 904-398-0835; E-mail: sgrenville4@aol.com



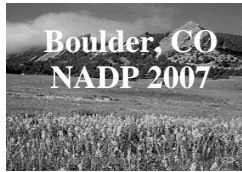
Deposition and Possible Sources of Organic Nitrogen in Rocky Mountain National Park

Katherine B. Beem^{*1}, Suresh Raja¹, Florian M. Schwandner¹, Amy P. Sullivan¹, Taehyoung Lee¹, Christian M. Carrico¹, Jeffrey L. Collett, Jr.¹, Sonia M. Kreidenweis¹, and William C. Malm²

Measurements of nitrogen deposition in and surrounding Rocky Mountain National Park took place during two campaigns of the Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS) Study. Measurements were made in a spring campaign during five weeks in March and April 2006, and in a summer campaign during five weeks in July and August 2006. RoMANS measurements of deposited nitrogen a significant fraction of nitrogen is deposited as organic species. Organic nitrogen contributed 11-53% of the total wet nitrogen deposition. Atmospheric organic nitrogen can include contributions from biological sources, oxidation products of combustion emissions, and reduced forms of nitrogen including organic analogs of ammonia. Agricultural environments, including Confined Animal Feeding Operations, are possible sources of reduced organic nitrogen in the RoMANS study area. Northeastern Colorado is a known major source area of agricultural ammonia emissions and previous studies indicate a correlation between ammonia and amine emissions in livestock feeding operation environments. At the time of the RoMANS, speciation of the forms of organic nitrogen in wet deposition was not performed. Recent efforts have been initiated to determine whether significant quantities of amines are present in the atmosphere near likely sources and at locations downwind. Initial efforts are focusing on collection of gas phase amines using diffusion denuders followed by analysis using ion chromatography.

^{*1}Corresponding author - Department of Atmospheric Science, Colorado State University, Atmospheric Science Dept, Fort Collins, CO 80523

²Cooperative Institute for Research in the Atmosphere, Colorado State University, CIRA, Fort Collins, CO 80523

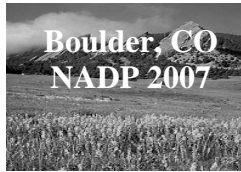


Assessment of Modeled Changes in Air Quality and Deposition Arising from Hypothetical Reductions in Anthropogenic Emissions over the Eastern US

Kevin Civerolo*, Winston Hao, and Gopal Sistla
New York State Department of Environmental Conservation
Division of Air Resources
625 Broadway, 2nd Floor
Albany, NY 12233-3259

In order to examine the effects of anthropogenic emissions on ambient ozone concentrations and nitrogen deposition across the eastern US, we performed sensitivity studies using the EPA Community Multiscale Air Quality (CMAQ) model. The model simulations covered an extended period (53 days) during the summer of 2002. In one simulation mobile source emissions were removed, and in the other all EGU and non-EGU point sources were removed. In terms of ozone concentrations, the greatest impacts of mobile sources were apparent in the southeastern US from Atlanta to North Carolina, as well as along the northeastern urban corridor. The greatest impacts of point sources followed the Ohio River Valley. The results were similar for N deposition, except that the effects of mobile source emissions in the southeastern US were not nearly as pronounced. These results suggest that effective air quality management may require different emissions strategies for different regions of the country.

*Corresponding author – Telephone: 518-402-8383; E-mail: kxcivero@gw.dec.state.ny.us

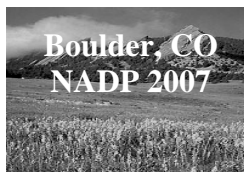


Estimated Trends in Wet Mercury Deposition at MDN Sites

Dr. Kevin Civerolo* and Gopal Sistla
New York State Department of Environmental Conservation
Division of Air Resources
625 Broadway, 2nd Floor
Albany, NY 12233-3259

With the proposed reductions in mercury EGU emissions in the coming years, it is instructive to examine current trends in mercury wet deposition. To this end we used the nonparametric Seasonal Kendall test to estimate trends at 49 MDN sites having at least seven years of data. Preliminary analysis suggests that 18 sites experienced statistically significant declines in mercury concentrations in wet deposition, despite the fact that trends in precipitation at these sites, although generally not significant, were found to be increasing at 31 of the 49 sites. There does not appear to be any clear geographic pattern to these significant declines, as these 18 sites were distributed across the MDN network. Changes in mercury deposition will be compared with changes in sulfate deposition at these locations. It will be important to continue this analysis as more data become available and more sites are brought on-line to assess the impacts of the Clean Air Mercury Rule and other emissions reductions programs over the next decade.

*Corresponding author – Telephone: 518-402-8383; E-mail: kxcivero@gw.dec.state.ny.us



2006 - 2007 Measurements of Atmospheric Mercury Species in Halifax, Nova Scotia

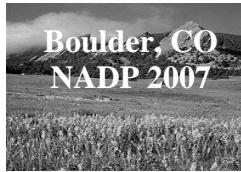
J. Dalziel and R. Tordon
Air Quality Sciences, Meteorological Service of Canada, Atlantic Region
Environment Canada, 45 Alderney Drive, Dartmouth, N.S. B2Y 2N6

Environment Canada's Atlantic Region has been running a sampling program to measure atmospheric mercury species from a site in Dartmouth, Nova Scotia since January 2006. This program was undertaken to determine the levels of gaseous Hg species – elemental mercury (Hg^0), reactive gaseous mercury (RGM), and the particulate (Hg_p) fine fraction ($<2.5 \mu\text{m}$) in an air shed impacted by both the local urban and marine environment.

The mercury species data discussed in this poster were collected from an eighteen month period - January 2006 to the end of June 2007. All sampling was carried out using a Tekran integrated sampling and analysis system consisting of the 2537A analyser, the 1130 RGM sampler and the 1135 particulate Hg sampler. This poster will illustrate the trends observed in gaseous Hg species with the on-site meteorological data - winds speed and direction, air temperature, relative humidity and solar radiation.

The data analysis from January 2006 to June 30, 2007 - show for Hg^0 (5 minute sampling) having a median of $\approx 1.7 \text{ ng/m}^3$ and a range of 0.72 to 46.5 ng/m^3 ; for RGM (3 hour sample) a median of $\approx 2.5 \text{ pg/m}^3$ with a range from the detection limit (dl) to 140 pg/m^3 and for Hg_p (3 hour sample) a median of 1.73 pg/m^3 and a range from dl to 31 pg/m^3 . The median level of RGM and Hg_p are a small percentage of the TGM, 0.14% for RGM and 0.10% for Hg_p which are similar to levels observed by other researchers.

*Corresponding authors – Telephone : 902-426-6791; E-Mail: john.dalziel@ec.gc.ca and rob.tordon@ec.gc.ca



Simulating Present-Day and Future Regional Air Quality as Climate Changes: Model Evaluation

John P. Dawson^{*1,2}, Pavan Nandan Racherla², Barry H. Lynn³,
Peter J. Adams^{2,4}, and Spyros N. Pandis^{1,5}

The Global-Regional Climate-Air Pollution modeling System (GRE-CAPS) has been developed, linking a general circulation model/chemical transport model (GCM/CTM), a regional meteorological model, and a regional chemical transport model (CTM). This modeling system has enabled the examination of the effects of changes in climate, intercontinental transport, and global and regional emissions on regional and urban air quality. The GRE-CAPS system consists of the GISS II' GCM/CTM, the MM5 regional meteorological model, and the PMCAMx regional CTM. Global-scale meteorology and pollutant concentration fields are generated by the GCM/CTM. Meteorology is downscaled to the regional level using MM5. Intercontinental transport is simulated by using the GCM/CTM-predicted concentrations around the edge of the regional CTM domain as chemical boundary conditions in the regional CTM.

The modeling system is evaluated for the present day, with model predictions compared to measured ozone and speciated PM_{2.5} measurements. Model predictions for five present-day Januaries and Julys are compared to measurements from the STN and IMPROVE databases from 2001-2005. Concentrations at 23 sites spread throughout the Eastern US modeling domain were used for comparisons. GRE-CAPS performed rather well in capturing present-day pollutant concentrations. Model biases and errors were similar to those for traditional model evaluation of historical air pollution episodes.

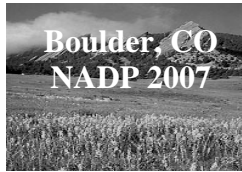
^{*1}Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh, PA

²Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA

³Department of Atmospheric Sciences, The Hebrew University of Jerusalem

⁴Department of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15231 Telephone: 412-268-5624; E-mail: petera@andrew.cmu.edu

⁵Department of Chemical Engineering, University of Patras, Patras, Greece



Sensitivity of Ozone and PM_{2.5} to Climate in the Eastern USA: A Modeling Case Study

John P. Dawson^{*1,2}, Peter J. Adams^{2,3}, and Spyros N. Pandis^{1,4}

In this work, sensitivities of ozone and PM_{2.5} concentrations to a suite of eight perturbations in meteorological parameters are examined. The modeling tool used in this case study is PMCAMx. The sensitivities of PM_{2.5} concentrations are studied in both July and January, while ozone concentrations are examined only in July. The modeled time periods include portions of July 2001 and January 2002. The meteorological parameters investigated include temperature, absolute humidity, wind speed, mixing height, cloud liquid water content and optical depth, cloudy area, precipitation rate, and precipitating area. Temperature increases generally led to increases in sulfate and decreases in nitrate. Changes in wind speed, mixing height, absolute humidity, and precipitation had appreciable effects on PM_{2.5} concentrations, while changes in cloud cover had little effect. Changes in temperature had the largest effect on ozone concentrations.

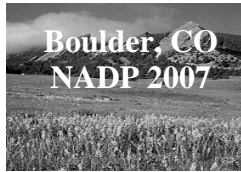
^{*1}Corresponding author - Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh, PA

²Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA

³Department of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15213 Telephone: 412-268-5624;

E-mail: petera@andrew.cmu.edu

⁴Department of Chemical Engineering, University of Patras, Patras, Greece



Life Cycle Assessment of Net Greenhouse Gas Flux for Bioenergy Cropping Systems

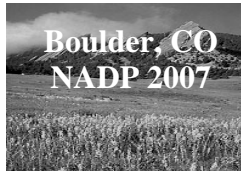
Steve Del Grosso^{*1}, Paul Adler², Bill Parton³, Sadie Skiles¹

Bioenergy cropping systems could help offset greenhouse gas emissions, but quantifying that offset is complex. Bioenergy crops offset carbon dioxide emissions by converting atmospheric carbon dioxide to organic carbon in crop biomass and soil, but they also emit nitrous oxide and vary in their effects on soil oxidation of methane. Growing the crops requires energy (e.g., to operate farm machinery, produce inputs such as fertilizer), and so does converting the harvested product to usable fuels (feedstock conversion efficiency). The objective of this study was to quantify all these factors to determine the net effect of several bioenergy cropping systems on greenhouse gas emissions. We used the DAYCENT biogeochemistry model to assess soil greenhouse gas fluxes and biomass yields for corn, soybean, alfalfa, hybrid poplar, reed canarygrass, and switchgrass as bioenergy crops in Pennsylvania. DAYCENT results were combined with estimates of fossil fuels used to provide farm inputs and operate agricultural machinery and fossil fuel offsets from biomass yields to calculate net greenhouse gas fluxes for each cropping system considered. Displaced fossil fuel was the largest greenhouse gas sink followed by soil carbon sequestration. N₂O emissions were the largest greenhouse gas source. All cropping systems considered provided net greenhouse gas sinks when the benefits of co-products were included. Compared with the life cycle of gasoline and diesel, ethanol and biodiesel from corn rotations reduced greenhouse gas emissions by about 40%, reed canarygrass by about 85%, and by about 115% for switchgrass and hybrid poplar.

^{*1}Corresponding author – USDA ARS NPA SPNR, 2150 Centre Ave., Building D, Suite 100, Fort Collins, CO 80526 Telephone: 970-492-7281; E-mail: delgro@nrel.colostate.edu

²USDA-ARS-Pasture Systems and Watershed Management Research Unit, Bldg. 3702 Curtin Road, University Park, PA 16807 Telephone: 814-865-8894; E-mail: paul.adler@ars.usda.gov

³NREL-CSU, 1231 East Drive, Fort Collins, CO 80523 Telephone: 970-491-1987



Analysis of Plastic Bag Liner Contamination NYSDEC Acid Deposition Program

Joan Fleser*, Allen Adams, Preston Lewis, Garry Boynton, Dr. Kevin Civerolo
New York State Department of Environmental Conservation
Division of Air Resources, Bureau of Air Quality Surveillance, 3rd Floor
625 Broadway, Albany, NY 12233-3256

New York State Department of Environmental Conservation (NYSDEC) has operated a statewide acid deposition monitoring program since the mid-1980s. The NYSDEC has provided crucial information on trends in wet deposition in rural, suburban, and urban locations throughout the state. This network complements the efforts of the federally-sponsored nationwide National Atmospheric Deposition Program (NADP) network, which focuses its efforts in largely rural areas. NYSDEC has been involved with the NADP equipment, methods and protocol sub-committees for several years.

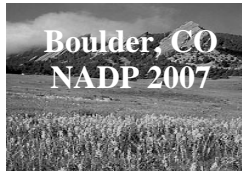
Unlike the NADP, wet deposition samples from the NYSDEC sites are collected on a weekly basis in buckets that are lined with polyethylene bags. NYSDEC staff has frequently recommended that NADP use plastic bag liners similar to NYSDEC and Environment Canada. However, NADP has expressed concern for bag contamination, even though routine analysis of potential contamination occurs when a new shipment of 5000 bags is received. Starting in November 2006 a team of involved staff was formed to analyze our bucket liners for contamination. The decision to do the study was not only to provide information for our acid deposition program but to also address some of the NADP concerns about using bucket liners because of potential significant contamination.

The Canadians use bucket liners, daily sampling, controlled shipping temperatures, etc which is quite different than our protocol. The Canadian specifications for purchasing plastic bags were very helpful to our study as we had not specified the parameters for a "clean bag". They also provided us some of their bags so we could cross check our lab results.

NADP provided us their control limits for clean buckets which they use in their collectors. This was also helpful in comparing definitions for clean bag parameters. After the NADP site operator places the sample into a lab bottle, the buckets are shipped back to Champaign, IL to be washed, sealed in a plastic bag and shipped back to the sites. The packing materials (cartons, etc.) and the shipping cost account for a considerable part of their program cost. It was because of this considerable cost that NYSDEC originally decided to use bags instead of buckets.

The team decided that we would keep our report brief and attached is a first draft gleaned mostly from the team's suggestions. Here we present results from an extensive study of potential contamination that may arise from the use of these polyethylene bags.

*Corresponding author - Telephone: 518-402-8508

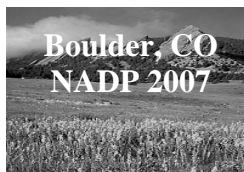


Have the Number Of Coastal or Easterly Precipitation Events in Southeastern NY Increased and How Does This Affect the Overall Trend in Precipitation Chemistry?

Victoria R. Kelly*, Kathleen C. Weathers and Gary M. Lovett
Institute of Ecosystem Studies
Box AB, Millbrook, NY 12545

An increase in the number of storms in the northeastern US that come from the east could have a strong influence on precipitation chemistry in that region. At our research site in southeastern New York, most storms come from the west, traveling through areas heavily populated by coal burning power plants and carrying pollutants that cause acid rain. On average, easterly and coastal storms have a higher pH and lower concentrations of sulfate and nitrate than storms that come from the west. The trend in precipitation concentrations of hydrogen ion, sulfate and nitrate since 1984 at the Institute of Ecosystem Studies is a decreasing one that corresponds to a decreasing trend in emissions of sulfur dioxide and oxides of nitrogen. If the number of easterly storms increases, the trend in average precipitation sulfur and nitrogen could take more of a downward trend than expected based on changes in sulfur and nitrogen emissions alone. In this paper, we examine the change in precipitation chemistry together with an analysis of storm direction during the period 1984-2006 to determine whether the changes in precipitation pH, sulfate and nitrate could, in part, be because the path of storms has changed and not only as a result of reductions in sulfur and nitrogen emissions.

*Corresponding Author – Telephone: (845) 677-5343; E-mail: KellyV@ecostudies.org



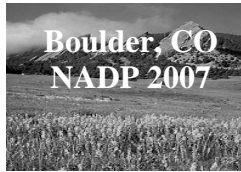
Investigation of the Accuracy of Methyl Mercury Measurements in Rainwater in the Presence of Increased Inorganic Mercury

Kate McPeck^{*1}, Lucas Hawkins¹, Eric Prestbo²

Measurements of mercury in rainwater are an important tool used to assess deposition rates into watersheds and other sensitive environments. Methyl mercury (MMHg) is of special concern due to its known toxicity to living organisms. For eight years MMHg has been measured at many National Atmospheric Deposition Program/Mercury Deposition Network (NADP/MDN) sites. This study investigates standard NADP/MDN sampling protocol for potential enrichment of wet MMHg deposition. For this experiment, inorganic mercury (Hg^{2+}) was added to rain collectors prior to deployment to test for a positive MMHg bias. Each collection event consisted of three samples spiked with 10 ng of Hg^{2+} and three control samples containing no Hg^{2+} spike. All samples were analyzed for total and methyl mercury via cold vapor atomic fluorescence spectrometry (CVAFS). A total of five weeklong sampling events resulting in 30 samples were collected in Seattle, WA from May 2006 to November 2006. The outside temperature during collection events ranged from 40-70°F. Results were evaluated using three statistical tests: paired t-test (mean delta=0.008ng/L, p=0.4579), linear regression (slope=1.0843), and linear regression with intercept forced through zero (slope=0.960). Preliminary results indicate that there is not enrichment of MMHg.

^{*1}Corresponding author - [Frontier](#) Geosciences, 414 Pontius Avenue North, Seattle WA 98109
Telephone: 206-622-6960; E-mail: katem@frontiergeosciences.com

²Tekran Canada R&D Facility, 330 Nantucket Blvd., Toronto, ON M1P2P4, Canada.



Relative Importance of Mercury Dry Deposition to MD08 in Western Maryland

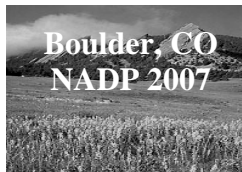
Chris Moore*¹, Mark Castro¹, John Sherwell² and Mark Garrison³

Mercury is constantly being deposited from the atmosphere to the Earth's surface, even in seemingly remote areas. The wet component of mercury deposition has been measured nationwide by the NADP Mercury Deposition Network. However, the dry component of mercury deposition has been sparsely measured. Estimates of dry deposition of mercury to the Piney Creek Reservoir in western Maryland (MD08) were obtained using three different models: CALPUFF, 'big leaf', and TEAM. In addition, we estimated dry deposition at MD08 using ambient air mercury concentrations (Hg(o), RGM and Hg-part) and different deposition velocities. In the first scenario, a deposition velocity of 0.01 cm s^{-1} was used for Hg(o), 0.1 cm s^{-1} for Hg-part and 0.5 cm s^{-1} for RGM. In the second scenario, the deposition velocity of RGM was increased to 2.0 cm/s to reflect the maximum range in observed RGM deposition velocities over land. The preliminary estimates using CALPUFF resulted in a total dry deposition of $19 \mu\text{g m}^{-2} \text{ yr}^{-1}$ to MD08, while the 'big leaf' and TEAM models estimated $10\text{-}15 \mu\text{g m}^{-2} \text{ yr}^{-1}$. Our total dry deposition estimate using the first scenario was $6.5 \mu\text{g m}^{-2} \text{ yr}^{-1}$, with 26 % from RGM, 71 % from Hg (o) and 3 % from Hg-part. For scenario two, total dry deposition was $11.9 \mu\text{g m}^{-2} \text{ yr}^{-1}$, with 60% from RGM, 39% from Hg(o), and less than 2% from Hg-part. These estimates vary by a factor of three and emphasize the uncertainty in current estimates of mercury dry deposition. The dry component of mercury deposition is similar to wet deposition at MD08, but the modeled dry component is highly variable. To improve model estimates and to obtain more accurate estimates of total mercury deposition to western Maryland, we need to measure dry deposition mercury at MD08. This information is also critical to assess the effectiveness of reductions in mercury emissions from power plants in the United States.

*¹Corresponding author – University of Maryland Center for Environmental Science Appalachian Laboratory, 301 Braddock Rd., Frostburg, MD; Telephone: 301-689-7191; E-mail: moore@al.umces.edu and E-mail: castro@al.umces.edu

²Maryland Department of Natural Resources, Annapolis, MD; E-mail: jsherwell@dnr.state.md.us

³ERM, Exton, PA; E-mail: garrison@erm.com



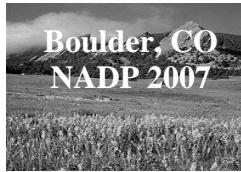
Real-time Rain Conductivity as a Surrogate for pH: Development of a Field-deployable Instrument

Alfred M. Moyle* and Dennis Lamb
Meteorology Department, 503 Walker Building
The Pennsylvania State University
University Park, PA 16802

The “daily” protocol of AIRMoN, compared with the “weekly” sampling of NTN, represents a significant improvement in the temporal resolution of wet-deposition data. Still, the single measurement of pH that AIRMoN currently provides on a given day represents only the broadest average of rain acidity; all the natural variability of the weather system is masked by the collection of a single rain sample. The fine temporal signature of individual storms at a given location, which might well reveal mechanistic information about cloud processes, is not available with the current monitoring strategy. In order to address the need for higher-resolution data, we have developed an economical, real-time, single-parameter monitor of precipitation quality.

Electrical conductivity, unlike pH, is relatively easy to measure, and its variations can be monitored continuously in time to give data representative of rain pH throughout a storm. In a presentation at the Fall 2006 NADP Technical Meeting, we described a manually-operated prototype instrument designed to measure the conductivity of precipitation in real-time and presented measurements made during a convective precipitation event in State College, PA on 28 September 2006. The prototype system has now been converted to an automatic, field-deployable form and is undergoing testing at our Scotia (PA15) field site. Initial results reveal that convective storms yield rain with highly variable conductivity (hence pH). It is hoped that routine measurements of conductivity may help unravel the temporal signature of rain pH and yield a wealth of new data about the chemical evolution of acidic storms.

*Corresponding author – Telephone: 814-863-4526; E-mail: amm14@psu.edu

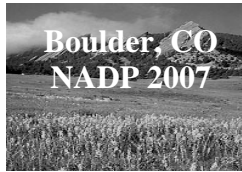


Hotspots of Nitrogen Cycling Activity in an Alpine-Subalpine Watershed on Niwot Ridge

Anthony Darrouzet-Nardi, Ph.D. Student
University of Colorado at Boulder
Department of Ecology and Evolutionary Biology
N122 Ramaley 334 UCB 80309-0334

Within a watershed, certain areas or components of it are likely to be hotspots of biogeochemical activity. This project was designed to locate nitrogen cycling hotspots within a heterogeneous alpine-subalpine watershed at the Niwot Ridge LTER site in the Front Range of the Rocky Mountains, Colorado. I used spatially explicit sampling methods to characterize soil moisture, soil temperature, pH, the nitrogen and carbon concentrations and stable isotope ratios in light and heavy soil fractions, nitrification rates, mineralization rates, and availability of inorganic nitrogen. Nitrogen concentration and isotope data suggest that within the forested areas, where plant diversity is limited to several trees, there are clear associations of nitrogen cycling activity with physical conditions such as temperature and moisture. However, within the open tundra and subalpine meadows, there is more heterogeneity, which may be associated with higher species diversity. There are also anomalous isotope values associated with the swampy areas that form at the sideslope-toeslope transition, suggesting that these are areas of interest for ecosystem processing of nitrogen.

*Corresponding author – Telephone: 303-304-6981; E-mail: anthony@darrouzet-nardi.net
<http://anthony.darrouzet-nardi.net/>

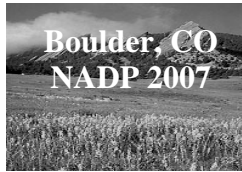


Environmental Factors that Affect Nylon and Teflon Filters used in Air Pollution Monitoring

Pamela Padgett
Atmospheric Deposition Unit
USDA Forest Service, Pacific Southwest Research
Riverside Fire Lab, 4955 Canyon Crest Dr, Riverside CA, 92507

Two proprietary filter media, Teflon (PTFE, PolyTetraFluoroEthylene) and Nylasorb (nylon) are used by both long term national monitoring networks and short term research-oriented monitoring projects. They are used in active monitoring systems such as the filter packs in the CASTNET program and in annular and honeycomb denuders, as well as passive monitoring systems used by many researchers and land managers. Both chemical and physical properties of the filters are engaged in trapping particulates and gasses. A series of experiments were conducted to evaluate the effects of ozone, relative humidity, and exposure time on the stability and reproducibility of these pollutant trapping materials. Variability in extract concentrations for NO_3^- , NH_4^+ and SO_4^{2-} within each experiment was <5% for all experiments, and little particulate decomposition was observed with extended operation and exposure. The presence of elevated ozone did, however, have a significant effect on capture or retention of HNO_3 on Nylasorb filters; the greater the ozone concentration, the lower the extractable NO_3^- . The effects of relative humidity were complicated by several other environmental factors, which will be highlighted in the presentation.

*Corresponding author – Telephone: 951-680-1584; E-mail: ppadgett@fs.fed.us

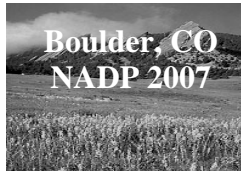


Importance of Deposition Measurements in Agro-Ecosystems A Perspective from Canadian Prairie Crops

E. Poscher*, M.P. Schellenberg, J.M. Clarke, H. Cutforth, M.R. Fernandez, and T.N. McCaig
Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada
1 Airport Road, Box 1030, Swift Current, SK S9H 3X2, Canada

Our study examines differences in heavy metal and metalloid concentrations in soils and crops across Saskatchewan. Western Canada is known for production of animal and plant foods in an area largely free of industrial and other anthropogenic sources of pollution. Therefore incidents of higher-than-desired levels of heavy metals and metalloids in agricultural crops are surprising but have occurred, such as the cases of cadmium in durum wheat, flax, and sunflower, and, most recently in 2006, selenium in yellow peas. Sources of these heavy metals and metalloids have remained unknown. It is generally assumed that these heavy metals and metalloids were derived from the soil. Atmospheric deposition may be another possible source for elevated heavy metals and metalloids found in crops, as wind-borne particles, sea salt spray, volcanoes, forest fires, energy production, mining, smelting, refining, manufacturing processes, waste incineration, transportation, and other natural and anthropogenic processes emit heavy metals into the atmosphere. How much of these emissions reach our agro-ecosystems, our crops, and our food chain? Some 30 years ago, the FAO issued a statement saying that "80% of chronic diseases are related to pollution", emphasizing the significance of pollutants to environmental and human health. Ever since this FAO statement, medical studies have shown that many chronic diseases may be metal-related, such as auto-immune diseases, allergies, autism, cancers, *inter alia*. The objective of our research study is to identify potential heavy metal point, area, and/or line sources in agricultural production systems by surveying the major food and feed crops including corresponding soil samples for possible heavy metal and metalloid accumulation across the province of Saskatchewan. The installation of four heavy metal monitoring stations in the Saskatchewan agro-ecosystem is envisioned to determine atmospheric deposition of heavy metals and metalloids onto agricultural soils and crops.

*Corresponding author – Telephone: 306-778-7285; E-mail: poschere@agr.gc.ca



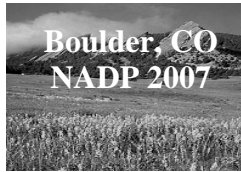
The Response of Surface Ozone to Climate Change over the Eastern United States

Pavan Nandan Racherla*¹, and Peter J. Adams^{1,2}

We examined the response of surface ozone to future climate change over the eastern United States by performing simulations corresponding to present (1990s) and future (2050s) climates using an integrated model of global climate, tropospheric gas-phase chemistry, and aerosols. A future climate has been imposed using ocean boundary conditions corresponding to the IPCC SRES A2 scenario for the 2050s decade, resulting in an increase in the global annual-average surface air temperature by 1.7°C, with a 1.4°C increase over the surface layer of the eastern United States. Present-day anthropogenic emissions and CO₂/CH₄ mixing ratios have been used in both simulations while climate-sensitive natural emissions were allowed to vary with the simulated climate. There is practically zero change in the spatiotemporally averaged ozone mixing ratios predicted over the eastern United States. However, the severity and frequency of ozone episodes over the eastern United States increased due to future climate change, primarily as a result of increased ozone chemical production due to increased natural isoprene emissions. The 95th percentile ozone mixing ratio increased by 5 ppbv and the largest frequency increase occurred in the 80-90 ppbv range. The most substantial and statistically significant (p -value < 0.05) increases in episode frequency occurred over the Southeast and Mid-Atlantic United States, largely as a result of 20% higher annual-average natural isoprene emissions. Increased chemical production and shorter average lifetime are consistent features of the predicted seasonal surface ozone response, with the former's magnitude for a location largely a function of increased natural isoprene emissions, and the latter largely due to faster dry deposition removal rates. Future climate change is also predicted to lengthen the ozone season over the eastern United States to include late spring and early fall. Significant interannual variability is observed in the frequency of ozone episodes and we find that it is necessary to utilize 5 years or more of simulation data in order to separate the effects of interannual variability and climate change on ozone episodes.

*¹Corresponding author - Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA

²Department of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15213 Telephone: 412-268-5624; E-mail: petera@andrew.cmu.edu



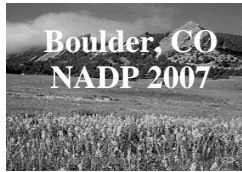
The Sensitivity of Regional Ozone Air Pollution Over the United States to Future Global Climate and Anthropogenic Emissions Changes

Pavan Nandan Racherla*¹, and Peter J. Adams^{1,2}

We examined the relative importance of future changes in climate, anthropogenic emissions, biogenic VOC emissions, CH₄, and long-range air pollution transport on U.S. O₃ by performing a suite of simulations with an integrated model of global climate, gas-phase chemistry and aerosols. Where applicable we used the A2 2050s climate as a representative future climate, and the A2 2050s (overall U.S. emissions increase) and B1 2050s (overall U.S. emissions decrease) emissions for future emissions. The model simulations show that U.S. O₃ is sensitive first and foremost to U.S. anthropogenic emissions changes, best illustrated in the domain-average changes in the average daily maximum 8-hour O₃ concentrations (MDA8-O₃) over the eastern U.S. (May-September) due to: 1) climate change with present-day anthropogenic emissions (2.1 ppbv); 2) anthropogenic emissions change alone (-9 to 9 ppbv); 3) climate change with different emissions regimes (0.9 to 3.4 ppbv); 4) increased global CH₄ concentration only (2.4 ppbv); and, 5) long-range air pollution transport (1.4 ppbv). The 95th-percentile O₃ increase (May-September) due to climate change with B1 and A2 emissions is 1 ppbv and 10 ppbv, respectively. Therefore, the climate change effect on O₃ is minimized under an emissions reduction scenario and amplified under an emissions increase scenario. Increased CH₄ and long-range transport (A2) together contribute 3.8 ppbv to the domain-average MDA8-O₃ (May-September), thereby increasing the O₃ background over the U.S. With more stringent O₃ standards in the future, this increased O₃ background could significantly reduce the benefits of likely drastic U.S. emissions reductions over the next several decades.

*¹Corresponding author - Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA

²Department of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15213 Telephone: 412-268-5624; E-mail: petera@andrew.cmu.edu



An Alternate Method for Creating a Statewide Isopleth Map of Total Mercury Wet Deposition with an Example for Indiana

Martin Risch*, Kathleen Fowler, and Nancy Baker
U.S. Geological Survey, 5957 Lakeside Blvd., Indianapolis, IN 46278

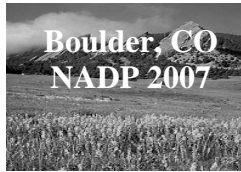
Valuable information about mercury in precipitation is illustrated by the National Atmospheric Deposition Program (NADP) through isopleth maps of annual mercury concentrations and mercury wet deposition at sites in the Mercury Deposition Network (MDN) in North America. These maps show the locations of MDN sites and list either the annual precipitation-weighted average total mercury concentration or the annual mercury wet deposition. More importantly, these maps illustrate an interpretation of the spatial distribution of ranges of mercury concentrations or mercury wet deposition, primarily in eastern North America, by use of colored isopleths. The isopleths are prepared with software in a geographic information system (GIS) that uses an inverse-distance weighting algorithm to estimate mercury concentrations or mercury wet deposition values for cells in a grid overlying eastern North America.

Isopleth maps of mercury wet deposition for an individual state derived from the NADP North America maps can lack the desired level of detail because the spatial distribution of sites is too sparse, and because the isopleth ranges are too broad for state-level interpretations. An alternate method for preparing a statewide map of total mercury wet deposition was utilized in an example for Indiana. Because mercury wet deposition is computed as the product of mercury concentration and precipitation, a wet deposition isopleth map was made by using precipitation data from a dense array of 127 National Weather Service (NWS) cooperative observer sites in Indiana.

To prepare the mercury wet deposition maps with the alternate method, a GIS was used to create an isopleth map of precipitation-weighted average mercury concentrations from MDN sites in Indiana and surrounding states, with data from 2001–2006. The Indiana map isopleths had a 0.5 nanogram per liter (ng/L) concentration range interval, compared with a 2 ng/L range found in the NADP maps. Average annual precipitation (2001–2006) for the 127 NWS sites was overlain with the mercury concentration isopleths map in order to assign a mercury concentration value for each NWS site. The concentration value that was associated with each NWS site was multiplied by the precipitation value for that site to obtain a mercury wet deposition value. The GIS then was used to create an isopleth map of mercury wet deposition for Indiana, based on the values computed for the 127 NWS sites.

The poster presents the methods and results of the alternate method, compares it with results from the (traditional) NADP method, and discusses limitations and uses of the new maps.

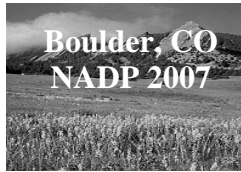
*Corresponding author – Telephone: 317-290-3333 x 163; E-mail: mrrisch@usgs.gov



Canada-United States Transboundary Transport and Wet Deposition of Sulphur and Nitrogen Oxides – A Mass Balance Approach

Robert Vet and Chul-Un Ro
Environment Canada, Science and Technology Branch, Air Quality Research Division
4905 Dufferin Street, Toronto, Ontario, M3H 5T4, Canada

Past acid deposition studies in North America have shown that SO_2 and NO_x emissions from Canada and the United States can be transported across the Canada-United States border and deposited in the other country. In this study, we estimate the percentage contribution of eastern US emissions to wet deposition in eastern Canada, and *vice versa*, in two five-year periods, 1990-1994 and 1996-2000. This is done using a set of mass balance equations derived from five-year-average total emissions in eastern Canada and the eastern US (taken from emission inventories) and five-year spatially-integrated wet deposition values (based on wet deposition measurements) in the same area. In deriving the mass balance equations, it was found that eastern Canada was responsible for only 8-9% of the total eastern North American SO_2 emissions but received 28-29% of the non-sea-salt-sulphate wet deposition, even though the area of integration in eastern Canada was approximately one half that of the eastern US. Similar figures were found for NO_x emissions and nitrate wet deposition. This emission/deposition imbalance is assumed to be due to transboundary transport and deposition – a term for which was included in the mass balance equations. The results suggest that SO_2 and NO_x emissions in the eastern US were responsible for 45 to 80% of the non-sea-salt- SO_4^{2-} (0.87-1.89 MT) and NO_3^- (0.84-1.51 MT) wet deposition in eastern Canada. Conversely, eastern Canadian emissions were estimated to be responsible for 0 to 16% of the non-sea-salt- SO_4^{2-} and NO_3^- wet deposition in the eastern US. Better resolution within these ranges is not possible given the limitations of the analysis. These results are consistent with other mass balance studies.



Assessing the Impact of Wet and Dry Nitrogen Deposition as an Ecosystem Stressor at Marine Corp Base Camp LeJeune (MCBCL), Jacksonville, North Carolina

Wayne P. Robarge^{*}, Karsten Baumann¹, Patricia Cunningham², and Susan Cohen³

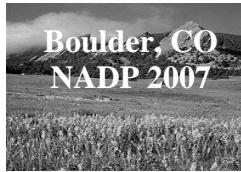
Long-term sustainability of our nation's military training bases is of critical importance to national security. In addition to training, which is the primary mission of most military bases, many military installations face land-use pressures due to assignment of increased military personnel, frequency and intensity of training, and proximity to growing urban areas and the resultant inability to expand in physical size (encroachment). Compliance with the Endangered Species Act and protection/generation of native habitats present additional pressures. This project is part of a larger effort, the Defense Coastal/Estuarine Research Program (DCERP) funded by the Strategic Environmental Research and Development Program, to identify significant ecosystem stressors and develop conceptual and mechanistic ecological models that will lead to effective management guidelines for the long-term sustainability of MCBCL near Jacksonville, N.C. MCBCL occupies over 60,000 ha in eastern North Carolina and extends from the Atlantic Ocean inland for ~ 24 km. MCBCL also constitutes a significant fraction of the New River watershed, which flows through the middle of the base. Wet deposition of nitrogen (N) will be monitored for 2 years using 4 National Atmospheric Deposition Program (NADP) style wet-dry collectors deployed along a transect across MCBCL from the Atlantic Ocean to Jacksonville, NC, which encroaches the base from the north. Sample collection, preservation and analysis will follow NADP guidelines, except that analysis of total dissolved organic-N will also be included in all analyses. Dry deposition of reduced and oxidized N species will be indirectly determined using throughfall/stemflow measurements within representative vegetative canopies at MCBCL (pine flatwoods, dry longleaf pine-wiregrass savanna, hardwoods). These measurements will be supplemented with passive samplers (ALPHA® samplers) to determine weekly average values of ambient ammonia and nitric oxide atmospheric concentrations, and with a network of tipping bucket gauges to measure rainfall amount along three transects across MCBCL. Repeated measures analysis will be used to assess concentration data and then combined with response surfaces generated from tipping bucket data to produce nutrient deposition maps. This combined approach will allow the assessment of the magnitude and temporal/spatial trends in N deposition (wet and dry) to the vegetative canopies and underlying soil-groundwater ecosystem across MCBCL. It will also provide baseline estimates of N deposition to compare local remobilization and deposition of N as a result of prescribed burning, which is a common land management practice in the Southeastern US and on MCBCL. This project will also estimate the magnitude and long-term trends in N deposition to the surrounding aquatic/estuarine ecosystems.

*Corresponding author - North Carolina State University, Department of Soil Science, Raleigh, NC 27695-7619 Telephone: 919-515-1454; E-mail: wayne_robarge@ncsu.edu

¹Atmospheric Research & Analysis, Inc., Cary, NC 27513

²RTI International, Research Triangle Park, NC 27709

³DCERP Coordinator, Marine Corp Base Camp LeJeune, NC 28543



Monitoring Ambient Ammonia Concentrations and Ammonia Dry Deposition Using Passive Samplers at the Pocosin Lakes National Wildlife Refuge in Eastern North Carolina

Wayne P. Robarge*, John T. Walker¹, and Sara Ward²

Confined animal feeding operations in North Carolina (especially in the Coastal Plain region) constitute the largest sources of ammonia (NH₃) emissions in the state. A moratorium on construction of new swine facilities during the past 8 years has essentially capped the NH₃ emissions from this segment of the animal industry. However, expansion of the poultry industry continues for broiler, layer and turkey production. This project is monitoring the potential impact of a new layer facility (eventual flock population 3.5 million birds) on local dry deposition of NH₃ to the nearby Pocosin Lakes National Wildlife Refuge, which lies within 1.6 km of the northern boundary of the new layer facility. For approximately one year prior to arrival of birds at the layer facility, background ambient ammonia chemistry was monitored using annular denuder technology at a fire tower within the refuge located approximately 9 km north of the facility. Annual mean concentrations of NH₃ and ammonium (NH₄) for 2005-2006 are summarized below:

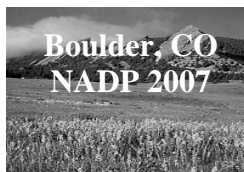
Statistic	Gaseous	Aerosol		
	NH ₃ - ug NH ₃ /m ³ -	NH ₄ - ug NH ₄ /m ³ -	SO ₄ - ug SO ₄ /m ³ -	Na - ug Na/m ³ -
Mean	0.491	0.482	3.67	0.124
Std. Deviation	0.456	0.387	2.02	0.103
Count	365	359	358	355
Minimum	0.011	0.003	0.024	0.007
Maximum	5.42	3.77	13.4	0.720

Weekly average NH₃ concentrations along transects extending across the northern boundary of the layer facility were monitored prior to January 2007 using GRADKO[®] passive samplers. No NH₃ concentrations were detected above the calculated detection limit of ~2 ug NH₃/m³, which is consistent with the background weekly average NH₃ concentrations recorded using annular denuder technology. With arrival of birds in January 2007, the GRADKO[®] passive samplers were replaced with ALPHA[®] passive samplers which have a calculated detection limit of <0.1ug NH₃/m³. Use of the more sensitive ALPHA[®] passive samplers has recorded elevated concentrations of NH₃ along transects extending across the northern boundary of the layer facility. Occurrences of elevated NH₃ concentrations are consistent with potential plumes of NH₃ originating from the layer facility. Weekly average NH₃ concentrations derived using passive samplers will be combined with micrometeorological data to calculate dry deposition. Backwards Lagrangian models will be used to model source strength of the facility and potential movement of NH₃ plumes deeper into the refuge.

*Corresponding author - North Carolina State University, Department of Soil Science, Raleigh, NC 27695-7619 Telephone: 919-515-1454; E-mail: wayne_robarge@ncsu.edu

¹U.S. Environmental Protection Agency, NRMRL, Research Triangle Park, NC 27711

²U.S. Fish and Wildlife Service, Raleigh Ecological Services Field Office, Raleigh, NC 27636

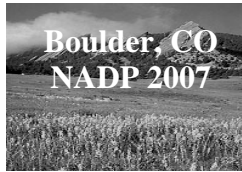


When Is Clean, Clean Enough?

Jane Rothert and Christopher Lehmann
Central Analytical Laboratory, Illinois State Water Survey
2204 Griffith Dr., Champaign, IL 61820

The Central Analytical Laboratory (CAL) for the National Atmospheric Deposition Program (NADP) has been providing clean sampling supplies for almost 30 years to the Atmospheric Integrated Research Monitoring Network (AIRMoN) and the National Trends Network (NTN). During this period, method detection limits have changed considerably, dropping by an order of magnitude for many analytes. Traditionally, sampling supplies were thought to be clean when laboratory blank analyte concentrations were below detectable levels. However this is no longer true, and may never have been fully true. The very low detection limits achieved in recent years with the CAL's newest generation of instruments allow the quantification of contamination in virtually all supplies provided to the NTN and AIRMoN. This poster will look at supply cleanliness for the past 11 years to see if supplies are getting dirtier or if the current lower detection limits simply make it possible to see contamination that wasn't visible in the past.

*Corresponding authors - Telephone: 217-244-0868; E-mail: Rothert@uiuc.edu,
clehmann@uiuc.edu



Ammonia Emissions from Animal Agricultural Operations: 2002 and Beyond

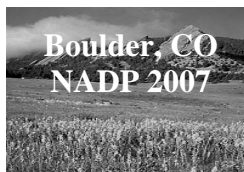
William Schrock and Gail Lacy
U.S. EPA, Office of Air Quality Planning and Standards

The increased size and consolidation of agricultural operations – including poultry, swine and dairy operations – have been the focus of an increasing number of citizen complaints and concern about possible health and environmental impacts. However, data on air emissions, including ammonia, from animal feeding operations (AFOs) are scarce. A 2002 report by the National Academy of Sciences called on EPA to improve its method for estimating emissions from AFOs – a key step in mitigating any air pollution from those operations.

In updating the National Emissions Inventory for ammonia for the year 2002, EPA laid the groundwork for estimating emissions using a process-based framework. This framework characterizes a wide variety of manure management trains, and includes emission factors to estimate the emissions from each of the processes within the manure management train. Estimates of the animal population subject to each of these management trains are input to develop national emission estimates. Nationally, poultry and beef production are the highest emitters, followed by dairy cattle and swine, although there are strong regional variations in the prevalence of each of these animal sectors.

Many data gaps in the emissions for each of the processes areas exist, including temporal (seasonal and diurnal) characterization. A multi-year research effort is underway with the ultimate goal a process-based emissions model. The study is funded through an air quality compliance agreement between EPA and the industry. Monitoring began in spring 2007 on 25 sites at 21 farms in 10 states. The farms monitored represent typical operations for different animals (swine, dairy cows and poultry) and different regions of the country. The selected farms had to meet several criteria related to practices commonly used by the industry, meteorological conditions and waste management methods. The states in which the farms are located are: California, Indiana, Iowa, Kentucky, New York, North Carolina, Oklahoma, Texas, Washington and Wisconsin. Particulate matter, hydrogen sulfide and volatile organic compounds are being monitored in addition to ammonia. Selected sites will be monitored for two years to ensure that the data account for seasonal variability as well as the impact of any operational changes. The two-year period also will help EPA determine whether the data are similar from one year to the next, and to account for any data anomalies. Monitoring will take place at barns, lagoons, and waste or manure storage piles. Land application sites are not included. A website is being developed to provide information related to the study, including monitoring protocols. Interim data will be made available on the website periodically.

*Corresponding author – Telephone: 919-541-5032; E-mail: schrock.bill@epa.gov
Telephone: 919-541-5261; E-mail: lacy.gail@epa.gov



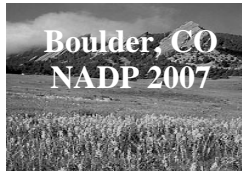
Airborne Gas and Particle Concentrations During the 2006 Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS) Study

Florian M. Schwandner*¹, Suresh Raja¹, Katherine B. Beem¹, Amy P. Sullivan¹, Taehyoung Lee¹, Gavin R. McMeeking¹, Christian M. Carrico¹, Courtney A. Gorin¹, Derek E. Day², Jeffrey L. Collett, Jr.¹, Sonia M. Kreidenweis¹, Jenny Hand² and William C. Malm²

In the *Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS)* study, airborne gas and fine particle concentrations were measured during spring (March - April) and summer (July - August) 2006. Sampling operations encompassed sites in Northern Colorado, centered in and around Rocky Mountain National Park (RMNP), spanning from Dinosaur National Monument in the West to Grant (NE) in the East. 24-hour integrated samples of gaseous ammonia, nitric acid and sulfur dioxide were acquired in tandem with fine particle (PM 2.5) concentrations of ammonium, nitrate, and sulfate. Results show substantially higher concentrations of ammonia at sites east of RMNP during both seasons. Gaseous ammonia concentrations exceeded concentrations of fine particle ammonium, and concentrations of both sulfur dioxide and nitric acid, at these eastern sites in both spring and summer. N(-III) tended to be more evenly split between gases and particles at higher elevation sites. N(V) tended to be fairly evenly split between gases and fine particles in the spring measurement period. Nitric acid concentrations generally exceeded fine particle nitrate concentrations during summer. During the hotter summer months, average gaseous nitrogen concentrations in northeastern Colorado were almost double the concentrations during the spring campaign. Sulfur dioxide concentrations were slightly higher in spring throughout the eastern and RMNP sites, while sulfate showed the opposite trend. Both 24 hr and higher time resolution measurements suggest that the highest concentrations of nitrogen species in RMNP are experienced during periods of transport from the east.

*¹Corresponding author - Dept. of Atmospheric Science, Colorado State University, Fort Collins, Colorado 80523-1371 Telephone: 970-491-8641; E-mail: fschwand@atmos.colostate.edu

²National Park Service/CIRA, Colorado State University, Fort Collins, Colorado



A New Inferential Deposition Model for Use in Network Operations

Donna Schwede*, Gary Lear¹

The Clean Air Status and Trends Network (CASTNET) is operated by the Clean Air Markets Division (CAMD) of the Office of Air Programs and the National Park Service to monitor concentration and dry deposition of sulfur and nitrogen species and ozone at sites across the country to assess long-term trends in air quality and environmental protection resulting from regulatory policies and emission reductions required under the Clean Air Act. CASTNET is considered the primary source for estimates of dry acidic deposition and is vital to the Agencies efforts in the protection of terrestrial and aquatic ecosystems. Additionally, concentration measurements from CASTNET are important to air programs in the development of SIPs and the evaluation of air quality models such as CMAQ.

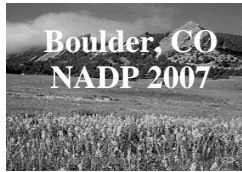
Since measurements of dry deposition flux are costly, CASTNET uses an inferential method to obtain these estimates whereby model-determined deposition velocities are paired with network measured concentrations. The model currently used for determining the deposition velocity is the Multilayer Model (MLM). A contractor runs the model using a Visual Basic interface and station specific site characteristics, meteorology and plant information. The deposition estimates along with measured concentrations and computed fluxes are maintained in a database. The database is provided to EPA and posted to their website for public access. The public does not have access to the interface.

Previous evaluations of the MLM showed good overall model performance, but indicated some potential areas for improvement. To address these areas, the Multilayer Biochemical (MLBC) model was developed which includes a state-of-the-science biochemical stomatal resistance model. Additional modifications were made to the water stress function, cuticular resistance, and soil surface resistance. The MLBC model was evaluated against several field studies and showed slightly better overall performance compared to the MLM and captured diurnal cycles better. EPA initiated an effort to adapt the research version of the MLBC model for use with CASTNET data. Beta versions of the revised model, MLBCNet, supporting databases, and the new Python interface for running the model have been completed. An overview of MLBCNet, the interface, and associated data is presented. MLBCNet was run for several CASTNET sites and comparisons of the deposition velocities from MLBCNet with those from the MLM model are provided.

Note: In partnership with the U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory.

*Corresponding author - NOAA/ARL/ASMD, MD E243-04, Research Triangle Park, NC 27711
Telephone: 919-541-3255; E-mail: donna.schwede@noaa.gov

¹Clean Air Markets Division, Office of Air and Radiation, U.S. Environmental Protection Agency



Modeling Long-Term Patterns of Speciated Mercury Concentrations in Maryland Using CALPUFF

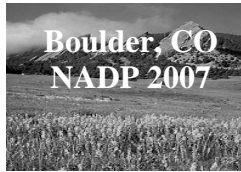
John Sherwell*, Tom Wickstrom¹, Anand Yegnan¹, Mark Garrison¹, Mark Castro², Chris Moore²

The Maryland Department of Natural Resources, Power Plant Research Program (PPRP) has provided support for the enhancement of a monitoring site at the Piney Reservoir in western Maryland by adding instrumentation (Tekran) that measures ambient speciated mercury on a continuous basis. Since the Piney site is part of several monitoring networks, a comprehensive set of concentration, deposition, and meteorological parameters are measured there. Nearly two years of continuous, speciated mercury concentrations are now available from the Piney site - elemental (HG0), reactive (Hg²⁺) and particulate (HgP). These data display seasonal, diurnal, and other patterns of mercury concentrations (including occasional large peaks of Hg²⁺) that can contribute to an understanding of the relative importance of local, regional, and global sources of mercury. PPRP has developed a modified version of the CALPUFF Lagrangian model to estimate mercury concentrations and deposition in Maryland. CALPUFF is capable of creating detailed source contribution matrices of mercury concentrations and deposition. While the CALPUFF model has demonstrated reasonably good performance when compared to weekly mercury deposition network (MDN) measurements, it has yet to be comprehensively evaluated with continuous concentrations. Success in predicting mercury concentrations is a necessary ingredient for estimating dry deposition, which may play an extremely important (but less-understood) role in mercury loading to watersheds and waterbodies due to atmospheric input. PPRP is taking the first step in this evaluation by comparing model predicted patterns with patterns measured at Piney. To develop the model predictions, a 10-year meteorological data set is used to examine the frequency and persistence of certain patterns. This poster will compare the model predictions over a ten-year period to measurements taken at Piney to provide insights into model performance related to speciated concentrations.

*Corresponding author – Maryland Power Plant Research Program (PPRP), 580 Taylor Ave., Tawes State Office Building, Annapolis, MD, 21401 Telephone: 410-260-8667; E-mail: jsherwell@dnr.state.md.us

¹ERM, 350 Eagleview Blvd., Exton, PA 19341

²University of Maryland Center for Environmental Science, 301 Braddock Rd., Frostburg, MD 21532

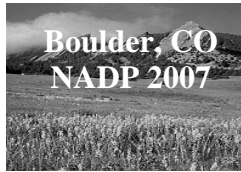


Short-term Variability of Stable Isotope Ratios of AIRMoN Precipitation Samples: The Influence of Precipitation Source on Isotopic Composition

Derek Sjoström*, Jeff Welker¹

The Atmospheric Integrated Research Monitoring Network (AIRMoN) program consists of a subset of NADP precipitation collection stations located throughout the eastern and central United States. At these locations, frequent sample collection has resulted in an extensive archive of precipitation that allows for analysis on the scale of individual precipitation events. Approximately 500 of these samples collected during 1996-2000 from Florida, Illinois, Ohio, Tennessee, Vermont, and West Virginia have been analyzed for δD and $\delta^{18}O$ in order to assess the short-term variability of the isotopic composition of precipitation. The isotopic composition of samples among precipitation events from all locations is highly variable. For example, δ values range by as much as approximately 100‰ for hydrogen and approximately 12‰ for oxygen for precipitation events separated by only a few days regardless of geographic location and time of year. There is a weak correlation between temperature at the time of the precipitation event and isotopic value of precipitation at all locations. In general, the long-established trends in isotopic values at different geographic locations are evident in this dataset. In order to assess how much of an influence precipitation source (storm track) has on the isotopic ratios for each storm event, storm back-trajectories were calculated for many data points using NOAA's HYSPLIT model. In general, where isotope value is similar among several storms, the modeled storm trajectories are fairly similar at most sites, with some exceptions. However, the results from Florida suggest that storm track is not the major control of isotopic ratios in precipitation; the amount effect and ambient temperature appear to be the dominant controls. Previous predictive models of isotopic ratios of precipitation have not included a storm track component. The addition of a precipitation source component to these models, which is the ultimate goal of this project, should help to refine and improve these models.

*Corresponding author - Dept. of Geological Sciences, University of Alaska Anchorage, 3211 Providence Dr., Anchorage, AK 99508 Telephone: 907-786-1372; E-mail: ands3@uaa.alaska.edu
¹Environmental and Natural Resources Institute, University of Alaska Anchorage, 707 A St., Anchorage, AK 99501 Telephone: 907-907-257-2701; E-mail: afjmw1@uaa.alaska.edu



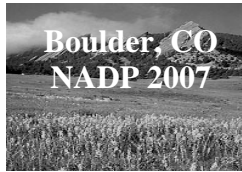
Improving and Optimizing the Detection Method for Flow Injection Analysis Using Calibration Extension and External Data Comparison

Scott Smith
Illinois State Water Survey
Central Analytical Laboratory
2204 Griffith Drive
Champaign, IL 61820

Flow Injection Analysis is the method used by the National Atmospheric Deposition Program/Central Analytical Laboratory (NADP/CAL) to detect and quantify ammonium and orthophosphate in collected National Trends Network (NTN) and Atmospheric Integrated Research Monitoring Network (AIRMoN) precipitation samples. This quantification is determined through the use of a Beer's law plot, in which standard solutions of known concentration are analyzed and the resulting peak areas are plotted linearly against the concentrations. By calculating the equation of the line running through these points, one can accurately determine the concentration of unknown samples based on peak areas. This method is only valid, however, within the range of the known standard concentrations. By adding additional standards throughout the curve, the range of detection can be extended and the accuracy of the extrapolated line can be improved as well.

Setting up a second FIA and reproducing the exact same run properties and conditions is another valid tool used to produce confidence in a detection method. Data comparisons can then be used to determine the reproducibility and validity of collected site data. This poster shows the results and procedures used to extend the FIA's calibration range and to set up and use a second FIA for data comparison.

*Corresponding author – Telephone: 217-333-8325; E-mail: srsmith@uiuc.edu



Airborne Road Deicing Salt at Suburban Chicago Sites

Gary J. Stensland* and Allen L. Williams¹

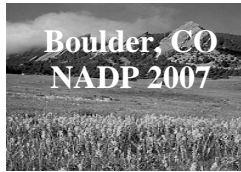
No comprehensive airborne road salt project had ever been done prior to the Illinois Department of Transportation (IDOT) funding for the Illinois State Water Survey (ISWS) to undertake such a project. IDOT funded ISWS to conduct a multi-year project which included measurements of airborne road salt at five permanent sites in the area of Lemont IL, just west of Argonne National Laboratory (ANL), which is about 25 miles southwest of downtown Chicago. I55, a SW-NE oriented 4 lane interstate highway (2 lanes in each direction) with large traffic flows, is expected to be the dominant source of airborne road salt in the Lemont area. The five Lemont sites were at perpendicular distances of .9 to 2.8 miles southeast of I55 while the NADP site IL19, at ANL, was 1.2 miles southeast of I55. Monthly measurements at the five Lemont sites included sodium, chloride, and other major ions from both the wet-side and dry-side of Aerochem Metric samplers, as well as from air quality filters using high volume aerosol samplers and dichotomous aerosol samplers. Road salt amounts applied by IDOT to the major highways in the many sub-areas of the Chicago metropolitan area, for all salting events from 1987 to 2004, were assembled by ISWS. For four road salting cases, snowfall grab samples were collected at ten sites on either side of I57, at distances from 200 to 2000 feet from interstate, and analyzed for the major ions.

An overview of results from this project will be presented. The air quality measurements at the five Lemont sites show that most of the sodium aerosol mass is in particles greater than 10 microns in diameter. Current air quality networks (IMPROVE and CASTNET) do not include measurements of particles greater than 10 microns. From the literature it can be suggested that even the high volume sampler may not efficiently capture the larger deicing salt particles present at distances greater than one mile from the emitting source road. Thus the dry-side bucket seems to be a reasonable choice to capture the deposition of these large aerosols.

The monthly data record for dry-side deposition at the five Lemont sites extends from 1997 to 2004 while the data record for the IL19 Argonne site was 1980-1998. The application of road deicing salt for state roads in the area was found to have a high linear correlation ($r^2=.75$) with salt dry deposited into the bimonthly dry-side samples at the IL19 site, for the period 1987-1997. It was estimated that at the NADP site, IL19, total sodium deposition due to road salt was about $103 \text{ mg/m}^2 /6$ winter months for dry-side deposition and $14 \text{ mg/m}^2 /6$ winter months for wet-side deposition.

*Corresponding author - Dakota Science, 311 E Holmes, Urbana, IL 61801
Telephone: 217-344-7919; E-mail: garysten@uiuc.edu

¹Center for Atmospheric Science, Illinois State Water Survey, Champaign, IL



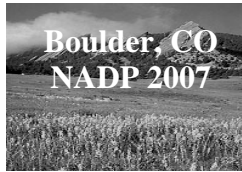
NADP/NTN Data Validation Coding and Use of Site History: Comparison of Utilizing Analyte Concentration vs. Analyte Deposition

Barbara Suever*, Jane Rothert and Tom Bergerhouse
Illinois State Water Survey, NADP/CAL
2004 Griffith Drive, Champaign, IL 61820

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is committed to providing high-quality, consistent data to researchers and other data users. One of our responsibilities is to ensure that contaminated samples have been thoroughly screened for anomalous chemistry. The NADP/NTN compares the concentration of analytes of incoming contaminated samples with the historical concentration of analytes for that site to determine if outliers occur. The program used to determine the historical concentrations for a site includes chemistry from all wet-type samples without noticeable contamination from the start-up of that site. Each chemistry value is then assigned a score based on its position within the distribution of that particular site's historical concentrations. If the score is ≥ 4 , a Screening Level (SL) code of "C" is assigned and that particular sample will be labeled as having anomalous chemistry or is considered to be contaminated. This is done to ensure that the chemistry from grossly contaminated samples is not used by researchers or other data users.

We have seen, over time, an ever-expanding distribution of chemistry data. This may result in a decrease of the frequency of SL coding with "C" and allow some samples that should be labeled as having anomalous chemistry pass through undetected. We hypothesized that utilizing the *deposition* of each analyte for site history, instead of *concentration*, would limit the expansion of the distributions and more accurately assign SL coding. Results from this study are presented in this poster with recommendations for future directions in regards to historical concentration usage.

*Corresponding author: Telephone: 217-333-1840; E-mail: bsuever@uiuc.edu



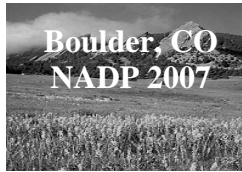
**Hach Environmental's OTT Pluvio Precipitation Gage
is Approved for Use at NADP Sites**

Kevin Sweeney
Hach Environmental

The NADP commissioned testing of modern precipitation gages beginning in 1998. The only precipitation gage that fully participated in all three phases of the formal test program, and continued field testing conducted through 2007, the OTT Pluvio from Hach Environmental is approved for use at NADP sites.

The OTT Pluvio is already in use in critical precipitation networks throughout the world by organizations including: NWS / ASOS, German Weather Service, Hydro Quebec, Swedish Meteorological and Hydrological Institute, Danish Institute of Agriculture and Royal Netherlands Meteorological Institute. NADP sites now have the opportunity to take advantage of its unmatched performance, functionality and reliability.

*Corresponding author – Telephone: 970-669-3050, x2590; E-mail: ksweeney@hach.com



**Seasonality of Precipitation Affects the Annual Isotopic ($\delta^{18}\text{O}$) Values
across the United States: A Sensitivity Study**

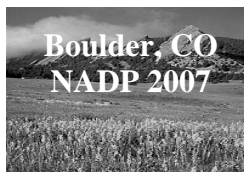
R.W. Vachon^{*1}, J.W.C. White¹, J.M. Welker², and E. Gutmann³

Year to year differences in the isotopes of precipitation ($\delta^{18}\text{O}$) are typically attributed to corresponding interannual changes in mean annual temperature. However, changes in the seasonal distribution of precipitation are one of the main complicating factors in interpreting year to year variability of $\delta^{18}\text{O}$ in precipitation. In this study, we investigate the influence of changes in seasonal distribution of precipitation on annually averaged isotopes using 73 sites across the entire United States. Based on these isotope measurements, and using multi-decadal records of the variance in monthly precipitation amounts, we identify areas within the United States where records of $\delta^{18}\text{O}$ in precipitation are susceptible to changes in the seasonal distribution of precipitation. Our findings indicate that the annual $\delta^{18}\text{O}$ values of precipitation in the Northern Great Plains, the Rocky Mountains, and the Southwest are strongly influenced by changes in the seasonal distribution of precipitation. To the contrary, shifts in the seasonal distribution of precipitation have almost no effect on the annual $\delta^{18}\text{O}$ values in the Eastern United States and along the West Coast. For the three regions most affected by the changes in seasonal distribution of precipitation, seasonality effects could be misinterpreted as 1°C to 3°C temperature changes between years. These findings facilitate a more accurate interpretation of climate records recorded in ice cores, tree rings, lake varves, plant segments, corals and speleothems.

^{*1}Institute of Arctic and Alpine Research, University of Colorado at Boulder

²Environment and Natural Resources Institute & Biology Department, University of Alaska Anchorage

³CSES/CIRES, University of Colorado at Boulder



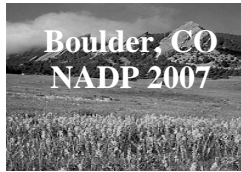
Wet and Dry Deposition Study: Texas Coastal Bend Bays and Estuaries Program (CBBEP)

Terry L. Wade^{*1}, Stephen T. Sweet¹ and Clyde W. Sweet² (retired)

Atmospheric deposition studies were instituted at two sampling sites on Corpus Christi Bay, Texas in 1997 as part of CBBEP. In 2002 the Texas A&M University, Corpus Christi (TAMUCC) site became an official NADP site (TX 39), the first located in close proximity to an urban/industrialized/estuarine area. The flux of inorganic nitrogen via atmospheric deposition was estimated from data collection that began in the late spring of 1997 and continued through September 1999 at the two sampling sites. Wet only rain samples were collected with an AeroChemetric rain sampler. Dry deposition (1997 to 1999) was estimated from analytes deposited to "clean water" in the dry side bucket of the AeroChemetric rain sampler. This study was the first attempt to characterize atmospheric loading rates of nitrogen in both wet and dry deposition to the Coastal Bend Bays estuaries. Dry deposition is dominated by ammonium at both the Texas A&M University Corpus Christi Station (TAMUCC) and at Whites Point Station (WP). Wet deposition of nitrogen directly to the coastal bend bays and estuaries ranges from 3.6 to 4.4 x 10⁵ kg and dry deposition ranges from 5.6 to 7.6 x 10⁵ kg based on rates from these two stations. The wet depositional rate of nitrate and ammonium at TAMUCC and at WP for 1998 was 1.15 and 1.36 kg N/ha-yr; 1.60 and 1.50 kg N/ha-yr, respectively. Wet deposition rates of nitrate at the two sites in Corpus Christi are similar to the NADP/NTN site located in Beeville, Texas (1.2 kg N ha⁻¹ yr⁻¹) and at the TAMUCC NADP (TX 39) in latter years; however, the ammonium flux is higher at Beeville, TX (2.0 kg N/ha-yr) for 1998. The dry depositional rate of nitrate and ammonium at TAMUCC and at WP for 1998 was 0.91 and 4.41 kg N/ha-yr, 1.31 and 2.60 kg N/ha-yr, respectively. Coupled studies (n = 8) of dry deposition to an empty AeroChemetric rain sampler bucket compared to one with clean water indicated similar collection efficiency for nitrate, but enhanced efficiency for ammonium. Based on these studies it is likely that NADP wet only nitrogen deposition for Coastal Bays Estuaries underestimates, by over a factor of 2, the actual nitrogen deposition.

¹Corresponding author - Geochemical and Environmental Research Group (GERG), Texas A&M University, 833 Graham Rd., College Station, TX 77845 Telephone: 979-862-2323, ext. 134; E-mail: terry@gerg.tamu.edu

²Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820-7495



Assessment of Atmospheric Nitrogen Deposition Response to EGU Pollution Controls for the Escambia Bay, Florida Watershed

Justin Walters^{*1}, Krish Vijayaraghavan², Jay L. Haney³, Rochelle Balmori²,
Shu-Yun Chen², Sharon G. Douglas³, Tom C. Myers³, John J. Jansen¹,
Eladio M. Knipping⁴, and Christian Seigneur²

A series of simulations using four air quality models were performed in order to assess atmospheric nitrogen deposition over Escambia Bay and its watershed in the western portion of the Florida panhandle and southern Alabama. This analysis is part of a larger study that used these data to drive two watershed models to estimate the impact of NO_x and SO₂ controls at a local coal-fired power plant on nitrogen loads to the bay. Model performance evaluations were conducted on the CMAQ-based models using observations from NADP, CASTNET, IMPROVE and SEARCH monitoring stations.

Three of the air quality models are 3-D Eulerian chemistry transport models derived from CMAQ version 4.5.1:

1. CMAQ-VISTAS: includes secondary organic aerosol modifications made for VISTAS RPO modeling;
2. CMAQ-MADRID: implements the Model of Aerosol Dynamics, Reaction, Ionization, and Dissolution (MADRID), including sectional particle size distribution, heterogeneous nitrate formation and sea-salt nitrate interactions; and
3. CMAQ-MADRID-APT: employs the advanced plume treatment (APT) module for the simulation of the plumes from 40 large coal-fired power plants in the southeastern United States including the plant under consideration.

The fourth air quality model is the California Puff Model (CALPUFF), a Lagrangian puff dispersion model with simpler parameterizations for chemistry and deposition processes.

Model simulations utilized previously developed meteorology and emission inputs for the base year of 2002. The Eulerian models were applied over a domain in the Southeast centered on Alabama and Georgia. CALPUFF was applied to a single power plant near Escambia Bay. The meteorology in all four models was driven by the same MM5 fields developed by the VISTAS RPO. Emissions and initial/boundary conditions were obtained from Georgia EPD, VISTAS, ICF and Southern Company, and are consistent for the three Eulerian models except for small differences in power plant emissions and wildfire emissions.

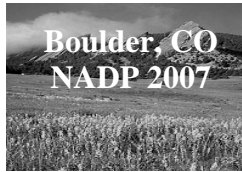
The presentation will present the results of the model performance evaluation and summarize the results from the four models in terms of total and speciated nitrogen deposition.

^{1*}Corresponding Author - Southern Company, 600 N. 18th St., 14N-8195, Birmingham, AL 35203
Telephone: 205-257-7558; E-mail: jwalters@southernco.com

²Atmospheric & Environmental Research, Inc., 2682 Bishop Dr., Ste 120, San Ramon, CA 94583

³ICF International, 101 Lucas Valley Road, Suite 260, San Rafael, CA 94903

⁴Electric Power Research Institute, 3420 Hillview Ave., Palo Alto, CA 94304



USGS External Quality Assurance Project Studies - Improving National Atmospheric Deposition Program Data Acquisition and Interpretation

Gregory A. Wetherbee and Natalie E. Latysh*
U. S. Geological Survey, Branch of Quality Systems

The U.S. Geological Survey (USGS) implements external quality assurance programs to measure and improve the integrity of National Atmospheric Deposition Program (NADP) data and data-collection systems. In addition to several long-term quality assurance studies, the USGS is evaluating four data-collection systems and their interpretation: 1) data telemetry systems for network monitoring and management; 2) altitude-dependent isopleth maps for spatial representation of atmospheric deposition; 3) wind shielding precipitation collectors to improve snow catch; and 4) urbanization of NADP sites.

Replacement of Belfort recording rain gages with more sophisticated electronic gages (ETI Noah-IV and OTT Pluvio-N) enables sites to be monitored remotely using telemetry systems. The USGS is evaluating two different satellite telemetry platforms and a cellular phone-based system to transmit data in near-real time. The near-real time data can inform site operators and network coordinators of instrument malfunction to limit lost data, improve representativeness of the NADP data, and assist in qualification of data.

Research of high altitude ecosystems would benefit from more accurate interpolated estimates of precipitation used in preparing NADP maps of annual wet deposition and annual precipitation-weighted mean concentration. The Parameter-elevation Regressions on Independent Slopes Model (PRISM) uses point measurements of precipitation and a digital elevation model (land surface altitude) to produce digital grid estimates of precipitation depth. The resulting maps using PRISM and NADP precipitation chemistry provide more realistic illustrations of total annual wet deposition in high altitude areas with complex terrain such as the Rocky Mountains. Estimation of the error inherent in the maps is needed before further consideration of using PRISM to create the maps.

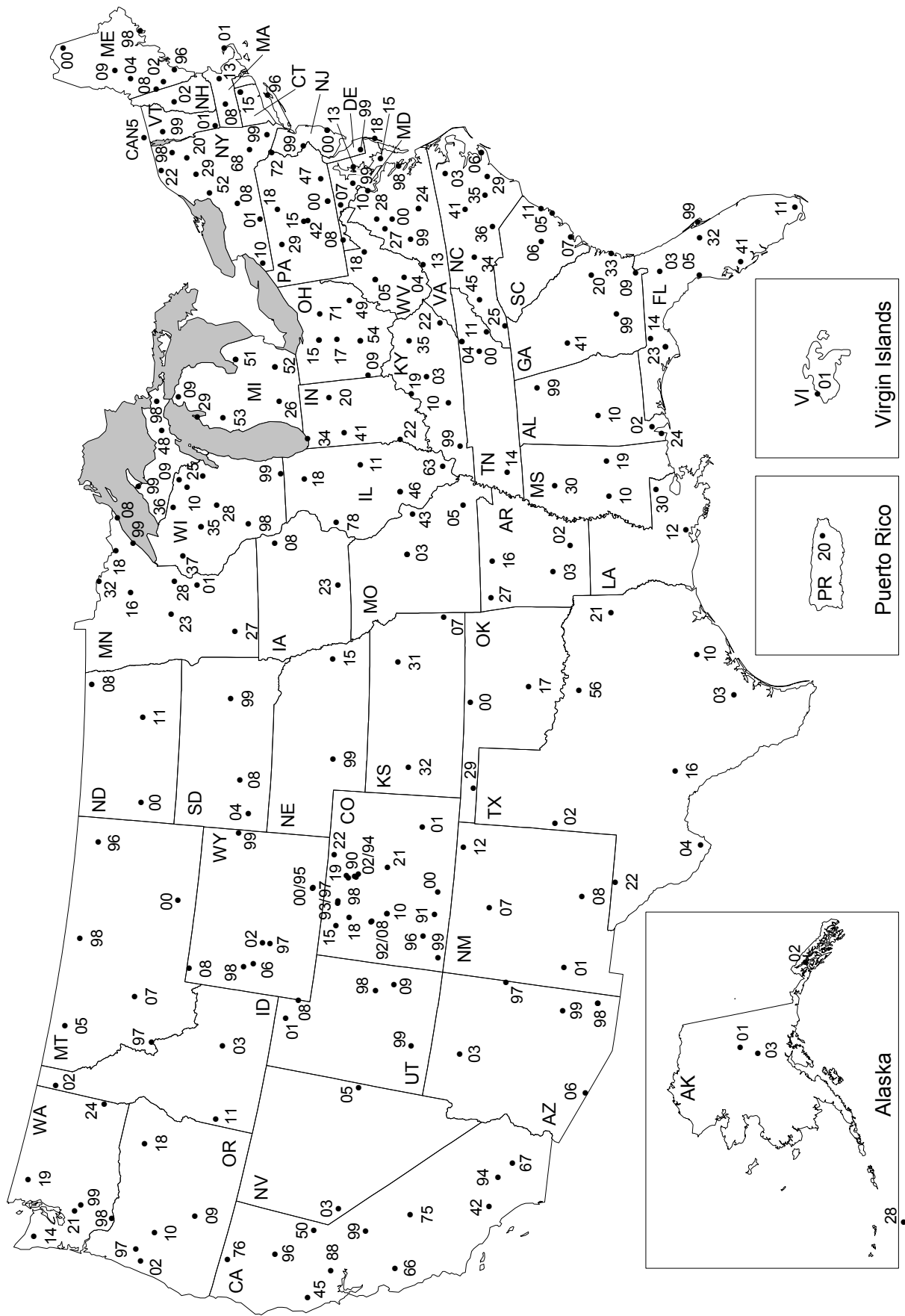
USGS is preparing to operate two co-located AeroChem Metrics precipitation collectors at the National Center for Atmospheric Research Marshall Field Site, located between Golden and Boulder, Colorado. One collector will be operated using standard NADP methods and the other using a fabric wind shield attached to the collector. Weekly catch efficiency differences will be monitored and, if warranted, chemical measurements will be made.

Finally, the project is preparing to study trends indicative of urbanization near selected NADP sites. Most NADP sites were located to measure regionally representative precipitation chemistry. Population growth and expansion of industry is occurring near sites originally selected to be unimpacted by local emission sources. The USGS study will attempt to identify which, if any, NADP sites are collecting data indicative of urban encroachment.

*Corresponding author – Telephone: 303-236-1880; E-mail: nlatysh@usgs.gov

NTN MAP AND SITE LISTINGS

National Atmospheric Deposition Program National Trends Network



**National Atmospheric Deposition Program/National Trends Network Sites
July 31, 2007**

State	Site Code	Site Name	Collocation	Sponsoring Agencies	Start Date
Alabama					
	AL02	Delta Elementary	MDN	US EPA/Mobile Bay Nat'l Estuary Prog & Dauphin Island Sea Lab	06/01
	AL10	Black Belt Research & Extension Center		US Geological Survey	08/83
	AL24	Bay Road	MDN	US EPA/Mobile Bay Nat'l Estuary Prog & Dauphin Island Sea Lab	05/01
	AL99	Sand Mountain Research & Extension Center		Tennessee Valley Authority	10/84
Alaska					
	AK01	Poker Creek		USDA Forest Service	12/92
	AK02	Juneau		USDA Forest Service/University of Alaska Southeast	06/04
	AK03	Denali NP - Mount McKinley		National Park Service - Air Resources Division	06/80
Arizona					
	*AZ03	Grand Canyon NP - Hopi Point		National Park Service - Air Resources Division	08/81
	AZ06	Organ Pipe Cactus NM		National Park Service - Air Resources Division	04/80
	AZ97	Petrified Forest NP-Rainbow Forest		National Park Service - Air Resources Division	12/02
	AZ98	Chiricahua		US Environmental Protection Agency-CAMD	02/99
	AZ99	Oliver Knoll		US Geological Survey	08/81
Arkansas					
	AR02	Warren 2WSW		US Geological Survey	05/82
	AR03	Caddo Valley		US Geological Survey	12/83
	AR16	Buffalo NR - Buffalo Point		National Park Service - Air Resources Division	07/82
	AR27	Fayetteville		US Geological Survey	04/80
California					
	CA28	Kings River Experimental Watershed		USDA Forest Service/Pacific Southwest Research Station	04/07
	CA42	Tanbark Flat		USDA Forest Service	01/82
	CA45	Hopland		US Geological Survey	10/79
	CA50	Sagehen Creek		US Geological Survey	11/01
	CA66	Pinnacles NM - Bear Valley		National Park Service - Air Resources Division	11/99
	CA67	Joshua Tree NP - Black Rock	MDN	National Park Service - Air Resources Division	09/00
	CA75	Sequoia NP - Giant Forest		National Park Service - Air Resources Division	07/80
	CA76	Montague		US Geological Survey	06/85
	CA88	Davis		US Geological Survey	09/78
	CA96	Lassen Volcanic NP - Manzanita Lake	MDN	National Park Service - Air Resources Division	06/00
	CA94	Converse Flats		Big Bear Municipal Water District	05/06
	CA99	Yosemite NP - Hodgdon Meadow		National Park Service - Air Resources Division	12/81
Colorado					
	CO00	Alamosa		US Geological Survey	04/80
	CO01	Las Animas Fish Hatchery		US Geological Survey	10/83
	CO02	Niwot Saddle		NSF-Institute of Artic & Alpine Research/University of Colorado	06/84
	CO08	Four Mile Park		US Environmental Protection Agency-CAMD	12/87
	CO10	Gothic		US Environmental Protection Agency-CAMD	02/99
	CO15	Sand Spring		Bureau of Land Management	03/79
	CO18	Ripple Creek Pass		Air Science Incorporated	05/03
	CO19	Rocky Mountain NP - Beaver Meadows		National Park Service - Air Resources Division	05/80
	CO21	Manitou		USDA Forest Service	10/78
	CO22	Pawnee		NSF-LTER/Colorado State University	05/79
	CO90	Niwot Ridge-Southeast		NSF-Institute of Artic & Alpine Research/University of Colorado	01/06
	CO91	Wolf Creek Pass		USDA Forest Service	05/92
	CO92	Sunlight Peak		US Environmental Protection Agency-CAMD	01/88
	CO93	Buffalo Pass - Dry Lake		USDA Forest Service	10/86
	CO94	Sugarloaf		US Environmental Protection Agency-CAMD	11/86
	CO96	Molas Pass		USDA Forest Service	07/86
	CO97	Buffalo Pass - Summit Lake	MDN	USDA Forest Service	02/84
	CO98	Rocky Mountain NP - Loch Vale		USGS/Colorado State University	08/83
	CO99	Mesa Verde NP - Chapin Mesa	MDN	US Geological Survey	04/81
Connecticut					
	CT15	Abington		US Environmental Protection Agency-CAMD	01/99
Delaware					
	DE99	Trap Pond State Park		US Environmental Protection Agency-CAMD	05/03

State	Site Code	Site Name	Collocation	Sponsoring Agencies	Start Date
Florida					
	FL03	Bradford Forest		St John's River Water Management District	10/78
	FL05	Chassahowitzka NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	08/96
	FL11	Everglades NP - Research Center	MDN	National Park Service - Air Resources Division	06/80
	FL14	Quincy		US Geological Survey	03/84
	FL23	Sumatra		US Environmental Protection Agency-CAMD	01/99
	FL32	Orlando	MDN	Seminole County Public Works Department	12/05
	FL41	Verna Well Field		US Geological Survey	08/83
	FL99	Kennedy Space Center		NASA/Dynamac Corporation	08/83
Georgia					
	GA09	Okefenokee NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	06/97
	GA20	Bellville		US Environmental Protection Agency-CAMD	04/83
	GA33	Sapelo Island		NSF/UGA, NOAA-NERR, & GA Dept of Natural Resources	11/02
	GA41	Georgia Station		SAES-University of Georgia	10/78
	GA99	Chula		US Geological Survey	02/94
Idaho					
	ID02	Priest River Experimental Forest		USDA Forest Service	12/02
	ID03	Craters of the Moon NM	MDN	National Park Service - Air Resources Division	08/80
	ID11	Reynolds Creek		US Geological Survey	11/83
Illinois					
	IL11	Bondville	AIRMoN/MDN	US Environmental Protection Agency-CAMD	02/79
	IL18	Shabbona		SAES-University of Illinois	05/81
	IL46	Alhambra		US Environmental Protection Agency-CAMD	01/99
	IL63	Dixon Springs Agricultural Center		SAES-University of Illinois	01/79
	IL78	Monmouth		US Geological Survey	01/85
Indiana					
	IN20	Roush Lake	MDN	US Geological Survey	08/83
	IN22	Southwest-Purdue Agricultural Center		US Geological Survey	09/84
	IN34	Indiana Dunes NL	MDN	National Park Service - Air Resources Division	07/80
	IN41	Agronomy Center for Research and Extension		SAES-Purdue University	07/82
Iowa					
	IA08	Big Springs Fish Hatchery		US Geological Survey	08/84
	IA23	McNay Memorial Research Center		US Geological Survey	09/84
Kansas					
	KS07	Farlington Fish Hatchery		US Geological Survey	03/84
	KS31	Konza Prairie		SAES-Kansas State University	08/82
	KS32	Lake Scott State Park		US Geological Survey	03/84
Kentucky					
	KY03	Mackville		US Geological Survey	11/83
	KY10	Mammoth Cave NP-Houchin Meadow	MDN	National Park Service - Air Resources Division	08/02
	KY19	Seneca Park		US Geological Survey	10/03
	KY22	Lilley Cornett Woods		NOAA-Air Resources Lab	09/83
	KY35	Clark State Fish Hatchery		US Geological Survey	08/83
	KY99	Mulberry Flats		TVA/Murray State University	12/94
Louisiana					
	LA12	Iberia Research Station		US Geological Survey	11/82
	LA30	Southeast Research Station		US Geological Survey	01/83
Maine					
	ME00	Caribou	MDN	NOAA-Air Resources Lab	04/80
	ME02	Bridgton	MDN	EPA/Maine Dept of Environmental Protection	09/80
	ME04	Carrabassett Valley		US Environmental Protection Agency-CAMD	03/02
	ME08	Gilead		US Geological Survey	09/99
	ME09	Greenville Station	MDN	EPA/Maine Dept of Environmental Protection	11/79
	ME96	Casco Bay - Wolfe's Neck Farm	MDN	EPA/Maine Dept of Environmental Protection	01/98
	ME98	Acadia NP - McFarland Hill	MDN	National Park Service - Air Resources Division	11/81
Maryland					
	MD07	Catoctin Mountain Park		National Park Service - Air Resources Division	05/03
	MD08	Piney Reservoir	MDN	MD DNR/University of Maryland-Appalachian Lab	06/04
	MD13	Wye		SAES-University of Maryland	03/83
	MD15	Smith Island		NOAA-Air Resources Lab	06/04
	MD18	Assateague Island NS - Woodcock		Maryland Department of Natural Resources	09/00
	MD99	Beltsville	MDN	Maryland Department of Natural Resources	06/04

State	Site Code	Site Name	Collocation	Sponsoring Agencies	Start Date
Massachusetts					
	MA01	North Atlantic Coastal Lab	MDN	National Park Service - Air Resources Division	12/81
	MA08	Quabbin Reservoir		Northeast States for Coordinated Air Use Management	03/82
	MA13	East		Northeast States for Coordinated Air Use Management	02/82
Michigan					
	MI09	Douglas Lake-University Michigan Biological Station		SAES-Michigan State University	07/79
	MI26	Kellogg Biological Station		SAES-Michigan State University	06/79
	MI29	Peshawbestown	MDN	US Environmental Protection Agency-CAMD	01/02
	MI48	Seney NWR - Headquarters	MDN	US Fish & Wildlife Service - Air Quality Branch	11/00
	MI51	Unionville		US Environmental Protection Agency-CAMD	01/99
	MI52	Ann Arbor		US Environmental Protection Agency-CAMD	01/99
	MI53	Wellston		USDA Forest Service	10/78
	MI98	Raco		US Environmental Protection Agency-CAMD	05/84
	MI99	Chassell		National Park Service - Air Resources Division	02/83
Minnesota					
	MN01	Cedar Creek		Minnesota Pollution Control Agency	12/96
	MN08	Hovland		Minnesota Pollution Control Agency	12/96
	MN16	Marcell Experimental Forest	MDN	USDA Forest Service	07/78
	MN18	Fernberg	MDN	US Environmental Protection Agency-CAMD	11/80
	MN23	Camp Ripley	MDN	US Geological Survey	10/83
	MN27	Lamberton	MDN	Minnesota Pollution Control Agency	01/79
	MN28	Grindstone Lake		Minnesota Pollution Control Agency	12/96
	MN32	Voyageurs NP - Sullivan Bay		National Park Service - Air Resources Division	05/00
	MN99	Wolf Ridge		Minnesota Pollution Control Agency	12/96
Mississippi					
	MS10	Clinton		US Geological Survey	07/84
	MS19	Newton		NOAA-Air Resources Lab	11/86
	MS30	Coffeeville		Tennessee Valley Authority	07/84
Missouri					
	MO03	Ashland Wildlife Area		US Geological Survey	10/81
	MO05	University Forest		US Geological Survey	10/81
	MO43	Tyson Research Center		Washington University-Tyson Research Center	08/01
Montana					
	MT00	Little Bighorn Battlefield NM		US Geological Survey	07/84
	MT05	Glacier NP - Fire Weather Station	MDN	National Park Service - Air Resources Division	06/80
	MT07	Clancy		US Geological Survey	01/84
	MT96	Poplar River		EPA/Fort Peck Tribes	12/99
	MT97	Lost Trail Pass		USDA Forest Service	09/90
	MT98	Havre - Northern Agricultural Research Center		US Geological Survey	07/85
Nebraska					
	NE15	Mead	MDN	SAES-University of Nebraska	07/78
	NE99	North Platte Agricultural Experiment Station		US Geological Survey	09/85
Nevada					
	NV03	Smith Valley		US Geological Survey	08/85
	NV05	Great Basin NP - Lehman Caves		National Park Service - Air Resources Division	01/85
New Hampshire					
	NH02	Hubbard Brook		USDA Forest Service	07/78
New Jersey					
	NJ00	Edwin B Forsythe NWR		US Fish & Wildlife Service - Air Quality Branch	10/98
	NJ99	Washington Crossing		US Environmental Protection Agency-CAMD	08/81
New Mexico					
	NM01	Gila Cliff Dwellings NM		New Mexico Environment Department	07/85
	NM07	Bandelier NM		DOE-Los Alamos National Lab	06/82
	NM08	Mayhill		US Geological Survey	01/84
	NM12	Capulin Volcano NM		New Mexico Environment Department	11/84

State	Site Code	Site Name	Collocation	Sponsoring Agencies	Start Date
New York					
	NY01	Alfred		US Geological Survey	08/04
	NY08	Aurora Research Farm		USDA/Cornell University	04/79
	NY10	Chautauqua		US Geological Survey	06/80
	NY20	Huntington Wildlife	MDN	EPA/SUNY-College of Environmental Science & Forestry	10/78
	NY22	Akwesasne Mohawk - Fort Covington		US Environmental Protection Agency-CAMD	08/99
	NY29	Moss Lake		US Geological Survey	07/03
	NY52	Bennett Bridge		EPA/State Univ of New York-Oswego	06/80
	NY68	Biscuit Brook	MDN	US Geological Survey	10/83
	NY96	Cedar Beach, Southold		EPA/Suffolk Dept of Health Service-Peconic Estuary Program	11/03
	NY98	Whiteface Mountain		US Geological Survey	07/84
	NY99	West Point	MDN	US Geological Survey	09/83
North Carolina					
	NC03	Lewiston		North Carolina State University	10/78
	NC06	Beaufort		US Environmental Protection Agency-CAMD	01/99
	NC25	Coweeta		USDA Forest Service	07/78
	NC29	Hofmann Forest		North Carolina State University	07/02
	NC34	Piedmont Research Station		North Carolina State University	10/78
	NC35	Clinton Crops Research Station		North Carolina State University	10/78
	NC36	Jordan Creek		US Geological Survey	10/83
	NC41	Finley Farms		North Carolina State University	10/78
	NC45	Mount Mitchell		North Carolina State University	11/85
North Dakota					
	ND00	Theodore Roosevelt NP-Painted Canyon		National Park Service-Air Resources Division	01/01
	ND08	Icelandic State Park		US Geological Survey	10/83
	ND11	Woodworth		US Geological Survey	11/83
Ohio					
	OH09	Oxford		US Geological Survey	08/84
	OH15	Lykens		US Environmental Protection Agency-CAMD	01/99
	OH17	Delaware		USDA Forest Service	10/78
	OH49	Caldwell		US Geological Survey	09/78
	OH54	Deer Creek State Park		US Environmental Protection Agency-CAMD	01/99
	OH71	Wooster		US Geological Survey	09/78
Oklahoma					
	OK00	Salt Plains NWR		US Geological Survey	12/83
	OK17	Great Plains Apiaries		NOAA-Air Resources Lab	03/83
	OK29	Goodwell Research Station		US Geological Survey	01/85
	OK99	Stilwell	MDN	US Environmental Protection Agency/Cherokee Nation	05/07
Oregon					
	OR02	Alsea Guard Ranger Station		US Environmental Protection Agency-CAMD	12/79
	OR09	Silver Lake Ranger Station		US Geological Survey	08/83
	OR10	H J Andrews Experimental Forest	MDN	USDA Forest Service	05/80
	OR18	Starkey Experimental Forest		US Geological Survey	03/84
	OR97	Hyslop Farm		US Environmental Protection Agency-CAMD	04/83
Pennsylvania					
	PA00	Arendtsville	MDN	US Environmental Protection Agency-CAMD	01/99
	PA15	Penn State	AIRMoN	NOAA-Air Resources Lab	06/83
	PA18	Young Woman's Creek		US Geological Survey	04/99
	PA29	Kane Experimental Forest		USDA Forest Service	07/78
	PA42	Leading Ridge		SAES-Pennsylvania State University	04/79
	PA47	Millersville	MDN	Pennsylvania Department of Environmental Protection	11/02
	PA72	Milford	MDN	USDA Forest Service	12/83
Puerto Rico					
	PR20	El Verde		USDA Forest Service	02/85
South Carolina					
	SC05	Cape Romain NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	11/00
	SC06	Santee NWR		US Geological Survey	07/84
	SC07	Ace Basin NERR		NOAA/South Carolina Department of Natural Resources	12/01
	SC11	North Inlet-Winyah Bay NERR		EPA/South Carolina Dept of Health and Environmental Control	01/02

State	Site Code	Site Name	Collocation	Sponsoring Agencies	Start Date
South Dakota					
	SD04	Wind Cave National Park-Elk Mountain		National Park Service - Air Resources Division	11/02
	SD08	Cottonwood		NOAA-Air Resources Lab	10/83
	SD99	Huron Well Field		US Geological Survey	11/83
Tennessee					
	TN00	Walker Branch Watershed	AIRMoN	DOE/Oak Ridge National Lab/Lockheed-Martin	03/80
	TN04	Speedwell		US Environmental Protection Agency-CAMD	01/99
	TN11	Great Smoky Mountain NP - Elkmont	MDN	National Park Service - Air Resources Division	08/80
	TN14	Hatchie NWR		Tennessee Valley Authority	10/84
Texas					
	TX02	Muleshoe NWR		US Geological Survey	06/85
	TX03	Beeville		NOAA-Air Resources Lab	02/84
	TX04	Big Bend NP - K-Bar		National Park Service - Air Resources Division	04/80
	TX10	Attwater Prairie Chicken NWR		US Geological Survey	07/84
	TX16	Sonora		US Geological Survey	06/84
	TX21	Longview	MDN	Texas Commission on Environmental Quality	06/82
	TX22	Guadalupe Mountains NP-Frijole Ranger Stn		US Geological Survey	06/84
	TX43	Cita Canyon		Texas A&M University	07/07
	TX56	LBJ National Grasslands		US Geological Survey	09/83
Utah					
	UT01	Logan		US Geological Survey	12/83
	UT08	Murphy Ridge		BP Amoco	03/86
	UT09	Canyonlands NP - Island in the Sky		National Park Service - Air Resources Division	11/97
	UT98	Green River		US Geological Survey	04/85
	UT99	Bryce Canyon NP - Repeater Hill		National Park Service - Air Resources Division	01/85
Vermont					
	VT01	Bennington		US Geological Survey	04/81
	*VT99	Underhill	AIRMoN/MDN	US Geological Survey	06/84
Virgin Islands					
	VI01	Virgin Islands NP - Lind Point		National Park Service - Air Resources Division	04/98
Virginia					
	VA00	Charlottesville		US Geological Survey	10/84
	VA10	Mason Neck Wildlife Refuge		Virginia Department of Environmental Quality	08/03
	VA13	Horton's Station		Tennessee Valley Authority	07/78
	VA24	Prince Edward		US Environmental Protection Agency-CAMD	01/99
	VA27	James Madison University Farm		US Environmental Protection Agency-CAMD	07/02
	VA28	Shenandoah NP - Big Meadows	MDN	National Park Service - Air Resources Division	05/81
	VA98	Harcum	MDN	Virginia Department of Environmental Quality	08/04
	VA99	Natural Bridge Station		Virginia Department of Environmental Quality	07/02
Washington					
	WA14	Olympic NP - Hoh Ranger Station		National Park Service - Air Resources Division	05/80
	WA19	North Cascades NP-Marblemount Ranger Stn		US Geological Survey	02/84
	WA21	La Grande		US Environmental Protection Agency-CAMD	04/84
	WA24	Palouse Conservation Farm		US Geological Survey	08/85
	WA98	Columbia River Gorge		USDA Forest Service - Pacific Northwest Region	05/02
	WA99	Mount Rainier NP - Tahoma Woods		National Park Service - Air Resources Division	10/99
West Virginia					
	WV04	Babcock State Park		US Geological Survey	09/83
	WV05	Cedar Creek State Park		US Environmental Protection Agency-CAMD	01/99
	WV18	Parsons		USDA Forest Service	07/78
Wisconsin					
	WI09	Popple River	MDN	Wisconsin Department of Natural Resources	12/86
	WI10	Potawatomi	MDN	EPA/Forest County Potawatomi Community	06/05
	WI25	Suring		Wisconsin Department of Natural Resources	01/85
	WI28	Lake Dubay		Wisconsin Department of Natural Resources	06/82
	WI35	Perkinstown		US Environmental Protection Agency-CAMD	01/99
	WI36	Trout Lake	MDN	Wisconsin Department of Natural Resources	01/80
	WI37	Spooner		Wisconsin Department of Natural Resources	06/80
	*WI98	Wildcat Mountain		Wisconsin Department of Natural Resources	08/89
	WI99	Lake Geneva	MDN	Wisconsin Department of Natural Resources	06/84

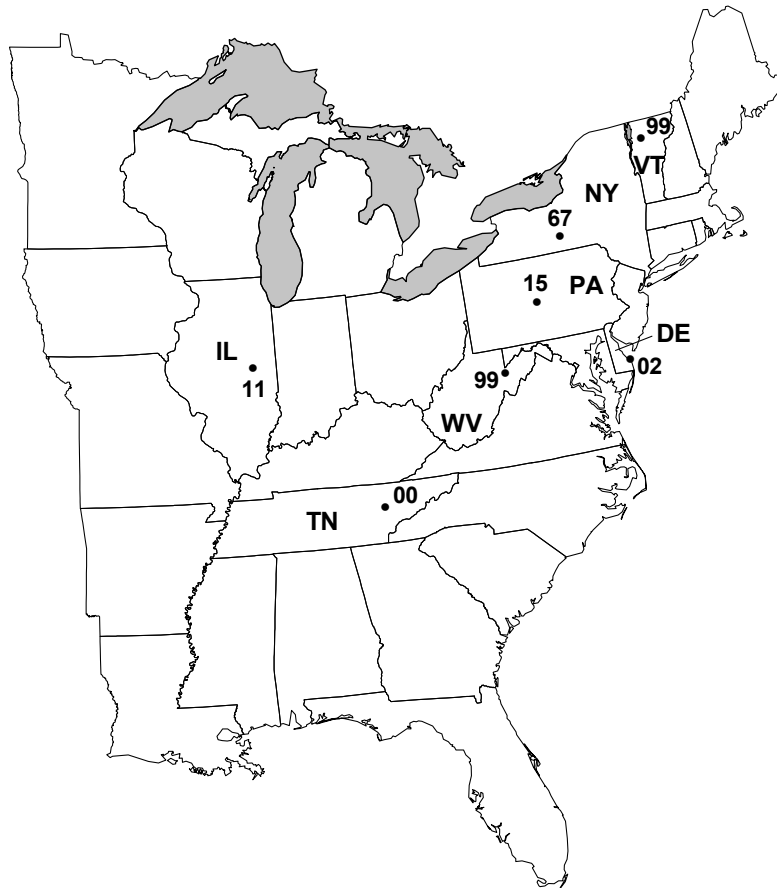
State					Start
Site Code	Site Name	Collocation	Sponsoring Agencies		Date
Wyoming					
WY00	Snowy Range		USDA Forest Service		04/86
WY02	Sinks Canyon		Bureau of Land Management		08/84
WY06	Pinedale		Bureau of Land Management		01/82
WY08	Yellowstone NP - Tower Falls	MDN	National Park Service - Air Resources Division		06/80
WY95	Brooklyn Lake		USDA Forest Service		09/92
WY97	South Pass City		USDA Forest Service/Bridger Teton NF		04/85
WY98	Gypsum Creek		USDA Forest Service/Bridger Teton NF		12/84
WY99	Newcastle		Bureau of Land Management		08/81
Canada					
CAN5	Frelighsburg		US Geological Survey		10/01

*At these sites the U.S. Geological Survey (VT99 & WI98) and National Park Service - Air Resources Division (AZ03) sponsor a second collector for measuring network precision.

AIRMON MAP AND SITE LISTING

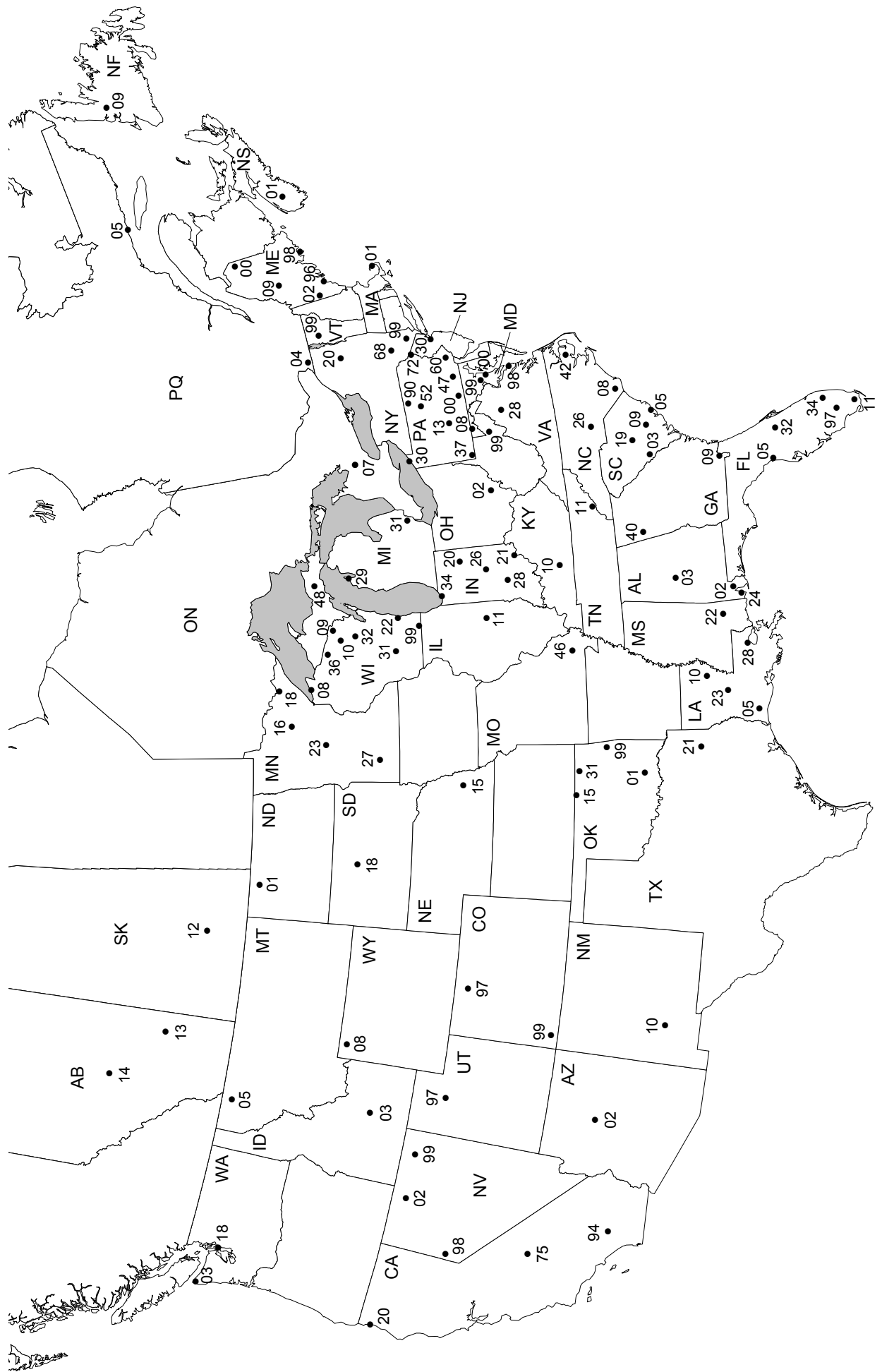
NADP/Atmospheric Integrated Research Monitoring Network Sites July 31, 2007

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Delaware DE02	Lewes		NOAA-Air Resources Laboratory	09/92
Illinois IL11	Bondville	MDN & NTN	NOAA-Air Resources Laboratory	10/92
New York NY67	Cornell University		NOAA-Air Resources Laboratory	09/92
Pennsylvania PA15	Penn State	NTN	NOAA-Air Resources Laboratory	10/92
Tennessee TN00	Oak Ridge National Lab	NTN	NOAA-Air Resources Laboratory	09/92
Vermont VT99	Underhill	MDN & NTN	NOAA-Air Resources Laboratory	01/93
West Virginia WV99	Canaan Valley Institute		NOAA-Air Resources Laboratory	06/00



MDN MAP AND SITE LISTINGS

National Atmospheric Deposition Program Mercury Deposition Network



**National Atmospheric Deposition Program/Mercury Deposition Network Sites
July 31, 2007**

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL02	Delta Elementary	NTN	EPA/Mobile Bay National Estuary Prog & Dauphin Island Sea Lab	06/01
AL03	Centreville		Southern Company/Atmospheric Research and Analysis, Inc	06/00
AL24	Bay Road	NTN	EPA/Mobile Bay National Estuary Prog & Dauphin Island Sea Lab	05/01
Arizona				
AZ02	Sycamore Canyon		EPA/Arizona Department of Environmental Quality	02/06
California				
CA20	Yurok Tribe-Requa		US Geological Survey	08/06
CA75	Sequoia NP-Giant Forest	NTN	National Park Service - Air Resources Division	07/03
CA94	Converse Flats	NTN	Big Bear Municipal Water District	04/06
Colorado				
CO97	Buffalo Pass - Summit Lake	NTN	USDA Forest Service-Rocky Mountain Research Station	09/98
CO99	Mesa Verde NP-Chapin Mesa	NTN	National Park Service - Air Resources Division	12/01
Florida				
FL05	Chassahowitzka NWR	NTN	US Fish & Wildlife Service - Air Quality Branch	07/97
FL11	Everglades NP - Research Center	NTN	South Florida Water Management District	*03/96
FL32	Orlando	NTN	St Johns River Water Management District	09/03
FL34	Everglades Nutrient Removal Project		South Florida Water Management District	07/97
FL97	Everglades - Western Broward County		South Florida Water Management District	11/06
Georgia				
GA09	Okefenokee NWR	NTN	US Fish & Wildlife Service - Air Quality Branch	07/97
GA40	Yorkville		Southern Company/Atmospheric Research and Analysis, Inc	06/00
Idaho				
ID03	Craters of the Moon NM	NTN	Idaho Department of Environmental Quality	10/06
Illinois				
IL11	Bondville	AIRMoN/NTN	NADP/Illinois State Water Survey	*01/99
Indiana				
IN20	Roush Lake	NTN	Indiana Department of Environmental Management/USGS	10/00
IN21	Clifty Falls State Park		Indiana Department of Environmental Management/USGS	01/01
IN26	Fort Harrison State Park		Indiana Department of Environmental Management/USGS	04/03
IN28	Bloomington		Indiana Department of Environmental Management/USGS	12/00
IN34	Indiana Dunes NL	NTN	Indiana Department of Environmental Management/USGS	10/00
Kentucky				
KY10	Mammoth Cave NP-Houchin Meadow	NTN	National Park Service - Air Resources Division	08/02
Louisiana				
LA05	Lake Charles		Louisiana Department of Environmental Quality	10/98
LA10	Chase		Louisiana Department of Environmental Quality	10/98
LA23	Alexandria		Louisiana Department of Environmental Quality	02/01
LA28	Hammond		Louisiana Department of Environmental Quality	10/98
Maine				
ME00	Caribou	NTN	University of Maine	05/07
ME02	Bridgton	NTN	EPA/Maine Department of Environmental Protection	06/97
ME09	Greenville Station	NTN	EPA/Maine Department of Environmental Protection	09/96
ME96	Casco Bay - Wolfe's Neck Farm	NTN	EPA/Maine Department of Environmental Protection	01/98
ME98	Acadia NP - McFarland Hill	NTN	NPS-Acadia NP & EPA/Maine Dept of Environmental Protection	*03/96

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Maryland					
	MD00	Smithsonian Environmental Res Ctr		MD DNR/Smithsonian Environmental Research Center	12/06
	MD08	Piney Reservoir	NTN	MD DNR/University of Maryland-Appalachian Lab	06/04
	MD99	Beltsville	NTN	Maryland Department of Natural Resources	06/04
Massachusetts					
	MA01	North Atlantic Coastal Lab	NTN	NPS - Cape Cod National Seashore	07/03
Michigan					
	MI29	Peshawbestown	NTN	EPA/Grand Traverse Band of Ottawa & Chippewa	05/07
	MI31	Sterling		US Geological Survey	09/05
	MI48	Seney NWR - Headquarters	NTN	US Fish & Wildlife Service-Air Quality Branch	11/03
Minnesota					
	MN16	Marcell Experimental Forest	NTN	USDA Forest Service-North Central Research Station & MNPCA	*02/96
	MN18	Fernberg	NTN	Minnesota Pollution Control Agency	*03/96
	MN23	Camp Ripley	NTN	Minnesota Pollution Control Agency	07/96
	MN27	Lamberton	NTN	Minnesota Pollution Control Agency	07/96
Mississippi					
	MS22	Oak Grove		Southern Company/Atmospheric Research and Analysis, Inc	06/00
Missouri					
	MO46	Mingo NWR		EPA/Missouri Department of Natural Resources	03/02
Montana					
	MT05	Glacier NP - Fire Weather Station	NTN	National Park Service - Air Resources Division	10/03
Nebraska					
	NE15	Mead	NTN	Nebraska Department of Environmental Quality	06/07
Nevada					
	NV02	Lesperance Ranch		Nevada Dept of Conservation & Natural Resources/Frontier Geosciences, Inc	01/03
	NV98	Reno		University of Nevada-Reno/Frontier Geosciences, Inc	10/06
	NV99	Gibb's Ranch		Nevada Dept of Conservation & Natural Resources/Frontier Geosciences, Inc	02/03
New Jersey					
	NJ30	New Brunswick		US Geological Survey	01/06
New Mexico					
	NM10	Caballo		Bureau of Reclamation/New Mexico State University	05/97
New York					
	NY20	Huntington Wildlife	NTN	EPA/Syracuse University	12/99
	NY68	Biscuit Brook	NTN	US Geological Survey	03/04
	NY99	West Point	NTN	US Dept of Education/John Jay College-City University of New York	10/06
North Carolina					
	NC08	Waccamaw State Park		North Carolina Dept of Environment & Natural Resources	*02/96
	NC26	Candor		North Carolina Dept of Environment & Natural Resources	11/05
	NC42	Pettigrew State Park		North Carolina Dept of Environment & Natural Resources	*02/96
North Dakota					
	ND01	Lostwood NWR		U S Environmental Protection Agency	11/03
Ohio					
	OH02	Athens Super Site		EPA/Ohio University	12/04
Oklahoma					
	OK01	McGee Creek		Oklahoma Department of Environmental Quality	10/06
	OK15	Newkirk		EPA/Cherokee Nation	03/05
	OK31	Copan		Oklahoma Department of Environmental Quality	10/06
	OK99	Stilwell	NTN	EPA/Cherokee Nation	04/03

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Pennsylvania					
	PA00	Arendtsville	NTN	PA Dept of Environmental Protection/Penn State University	11/00
	PA13	Allegheny Portage Railroad NHS		PA Dept of Environmental Protection/Penn State University	01/97
	PA30	Erie		PA Dept of Environmental Protection/Penn State University	06/00
	PA37	Holbrook		Electric Power Research Institute	05/99
	PA47	Millersville	NTN	PA Dept of Environmental Protection/Penn State University	11/02
	PA52	Little Pine State Park		PA Dept of Environmental Protection/Penn State University	07/07
	PA60	Valley Forge		PA Dept of Environmental Protection/Penn State University	11/99
	PA72	Milford	NTN	PA Dept of Environmental Protection/Penn State University	09/00
	PA90	Hills Creek State Park		PA Dept of Environmental Protection/Penn State University	01/97
South Carolina					
	SC03	Savannah River		US Dept of Energy/Washington Savannah River Company	01/01
	SC05	Cape Romaine NWR	NTN	US Fish & Wildlife Service - Air Quality Branch	03/04
	SC09	Alibi Hunt Club		US Geological Survey	11/05
	SC19	Congaree Swamp		South Carolina Dept of Health & Environmental Control	*03/96
South Dakota					
	SD18	Eagle Butte		EPA/Cheyenne River Sioux Tribe	03/07
Tennessee					
	TN11	Great Smoky Mountains NP-Elkmont	NTN	National Park Service - Air Resources Division	01/02
Texas					
	TX21	Longview	NTN	Texas Commission on Environmental Quality	*03/96
Utah					
	UT97	Salt Lake City		Utah Department of Environmental Quality	05/07
Virginia					
	VA28	Shenandoah NP-Big Meadows	NTN	National Park Service - Air Resources Division	10/02
	VA98	Harcum	NTN	Virginia Department of Environmental Quality	12/04
Vermont					
	VT99	Underhill	AIRMoN/NTN	NOAA-ARL/University of Vermont	07/04
Washington					
	WA03	Makah National Fish Hatchery		US Geological Survey	03/07
	**WA18	Seattle - NOAA		Illinois State Water Survey & Frontier Geosciences Inc	03/96
West Virginia					
	WV99	Canaan Valley Institute	AIRMoN	NOAA - Air Resources Lab	06/07
Wisconsin					
	**WI08	Brule River		Wisconsin Department of Natural Resources	*03/96
	WI09	Popple River	NTN	Wisconsin Department of Natural Resources	*03/96
	WI10	Potawatomi	NTN	EPA/Forest County Potawatomi Community	06/05
	WI22	Milwaukee		Wisconsin Department of Natural Resources	10/02
	WI31	Devils Lake		Wisconsin Department of Natural Resources	01/01
	WI32	Middle Village		EPA/Menominee Indian Tribe	01/02
	WI36	Trout Lake	NTN	Wisconsin Department of Natural Resources	*03/96
	WI99	Lake Geneva	NTN	Wisconsin Department of Natural Resources	01/97
Wyoming					
	WY08	Yellowstone NP-Tower Falls	NTN	Wyoming Department of Environmental Quality	10/04
CANADA					
Alberta					
	AB13	Henry Kroeger		ATCO Power	09/04
	AB14	Genesee		TransAlta/EPCOR Generation Inc.	07/06
Newfoundland					
	NF09	Cormak		Environment Canada	05/00

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Nova Scotia	NS01	Kejimikujik NP		Environment Canada	07/96
Ontario	ON07	Egbert		Environment Canada	03/00
Quebec	PQ04	Saint Anicet		Environment Canada	04/98
	PQ05	Mingan		Environment Canada	04/98
Saskatchewan	SK12	Bratt's Lake BSRN		Environment Canada	05/01

*These dates mark the official start of NADP/MDN operations. Data for a transition network operating in 1995 and early 1996 are available from the NADP web site at http://nadp.sws.uiuc.edu/mdn/mdn_trandata_rpt.html.

**At this site the NADP Program Office sponsors a second collector for the purpose of measuring network precision.

PROCEEDINGS NOTES

