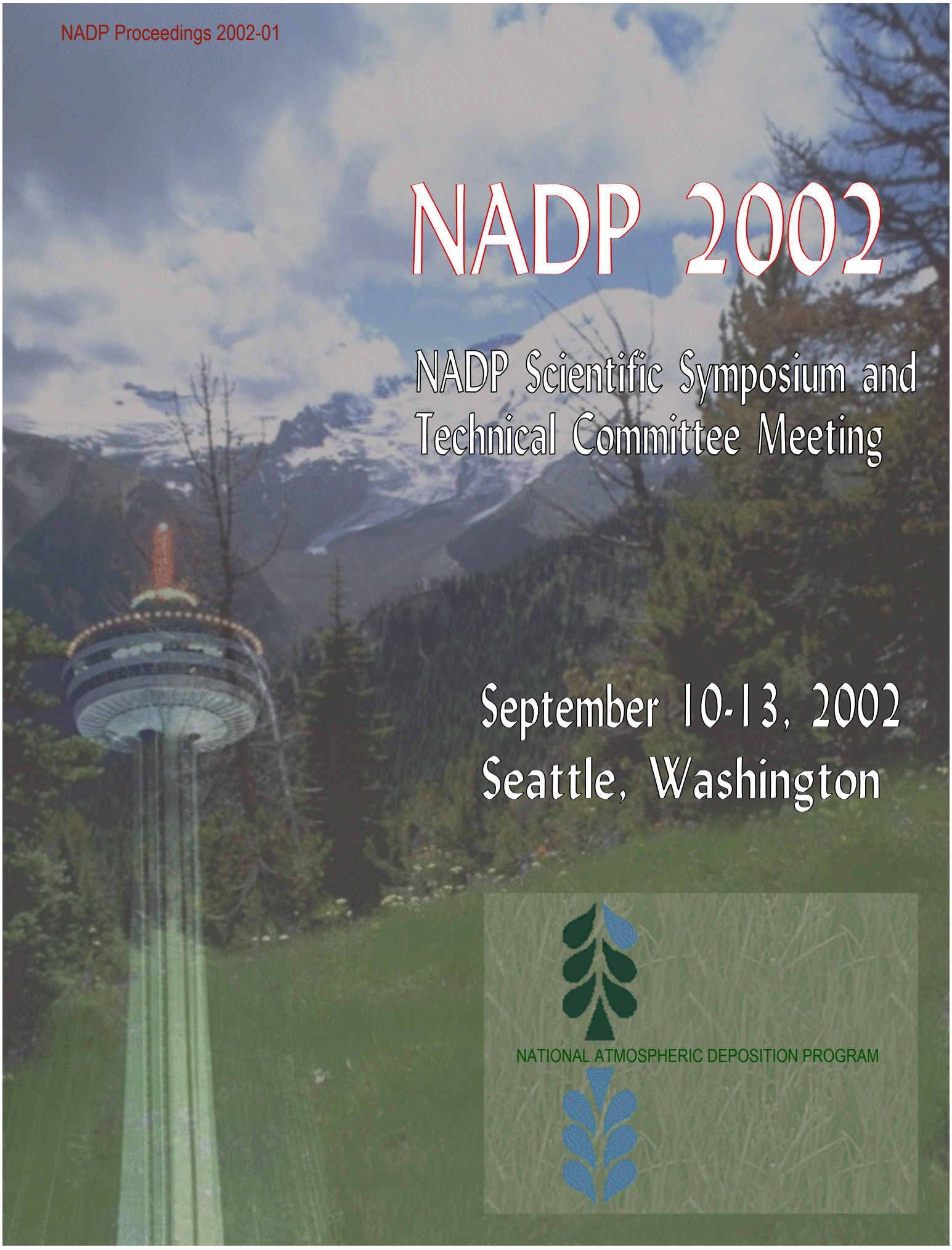
NADP Proceedings 2002-01



NADP 2002

NADP Scientific Symposium and Technical Committee Meeting

September 10-13, 2002
Seattle, Washington

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

In 2001, scientists, students, educators, and others interested in National Atmospheric Deposition Program (NADP) data logged nearly 110,000 sessions on the NADP Internet site. They made more than 18,000 on-line data retrievals and viewed maps nearly 88,000 times. These data are used to address important questions about the impact of the wet deposition of nutrients on eutrophication in coastal estuarine environments; the relationship between wet deposition, the health of unmanaged forests, and the depletion of base cations from forest soils; the impact of pollutant emissions changes on precipitation chemistry; and the rate at which precipitation delivers mercury to remote lakes and streams.

The NADP was organized in 1977 under the leadership of State Agricultural Experiment Stations (SAES) 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 acidic chemicals, nutrients, and base cations. The NADP was initially 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, SAES reclassified IR-7 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, NADP agreed to coordinate operation of NAPAP's National Trends Network (NTN). To benefit from shared siting criteria, identical operating procedures, and a shared analytical laboratory, NADP and NTN merged with the designation NADP/NTN. Many sampling sites are supported by the U.S. Geological Survey (USGS), 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 nearly 250 sites in the network, and the network designation has been shortened to NTN.

In the 1990s, NADP expanded to include two additional networks. The Atmospheric Integrated Research Monitoring Network (AIRMoN), which currently has ten sites, joined NADP in October 1992. AIRMoN sites collect samples daily when precipitation occurs. Samples are refrigerated until analysis at the CAL for the same constituents measured in NTN samples. AIRMoN seeks to identify pollutant source/receptor relationships and the effect of emissions changes on precipitation chemistry, combining measurements with atmospheric models. AIRMoN also evaluates new sample collection and preservation methods. Another NADP network, the Mercury Deposition Network (MDN), currently has nearly 70 sites and joined NADP in 1996. MDN sites collect wet-only deposition samples that are sent to a laboratory specializing in mercury measurements. Frontier Geosciences, Inc. analyzes all samples for total mercury and some samples for methyl mercury. The MDN collects data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors. Forty-three 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 importance of the atmospheric deposition of mercury as a cause of this problem.

A number of federal agencies support the NADP: U.S. Geological Survey; National Park Service; Environmental Protection Agency; National Oceanic and Atmospheric Administration; U.S. Department of Agriculture - Forest Service; Bureau of Land Management; U.S. Fish & Wildlife Service; Tennessee Valley Authority; and U.S. Department of Agriculture - Cooperative State Research, Education, and Extension Service under Agreement No. 98-COOP-1-5925. Additional support is provided by various other federal agencies, State Agricultural Experiment Stations, state agencies, universities, and public and private research organizations. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author and do not necessarily reflect the view of the U.S. Department of Agriculture or any other sponsor.

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The Illinois State Water Survey is an Affiliated Agency of the University of Illinois and a Division of the Illinois Department of Natural Resources

NADP SCIENTIFIC SYMPOSIUM
AND
TECHNICAL COMMITTEE MEETING

Proceedings

Seattle, Washington
September 10-13, 2002

Technical Program Chair
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September 2002

A special thank you to those responsible for making the 2002 National Atmospheric Deposition Network Scientific Symposium and Technical Committee Meeting a success. Kathy McCormick is responsible for arranging the meeting facilities, catering and budgets. Roger Claybrooke provides the maps for the proceedings booklet as well as the maps for the annual map summaries. Thanks also goes to Sarah Milton and Nichole Samson for their production of the CALendar. Joyce Fringer and Pamela Bedient, administrative coordinators for the NADP, provide untiring support for the staff of the NADP.

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NADP TECHNICAL COMMITTEE MEETING AGENDA

	September 10, 2002	September 11, 2002	September 12, 2002	September 13, 2002
Time	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
0700	**Executive Committee Meeting Shaw Room**	**Registration Open**	**Registration Open**	
0800		**Technical Committee Business Meeting (Lopez Room)**	**Stable Isotopic Measurements - A New Application for NADP Samples**	
0820			**Karen Harlin, ISWS, Chair**	
0840				
0900	**(break)**		**Changing Government Policy From Clean Air to Clear Skies Gary Lear, US EPA, Chair**	
0920	**Joint Sub-Committee Meeting (Registration Open) Shaw and Fidalgo Rooms**			
0940				
1000		**(break)**		
1020		**Mercury Emissions Bob Brunette, Frontier Geosciences, Chair**	**(break)**	
1040			**Changing Precipitation Chemistry and Its Effects Robert Larson, ISWS, Chair**	
1100				**Field Trip Mount Rainier National Park (box lunch provided)**
1120				
1140	**Lunch (on your own)**			
1200		**Lunch (on your own)**	**Lunch (on your own)**	
1300	**Sub-Committee Meetings**	**Mercury Deposition and Effects Eric Prestbo, Frontier Geosciences, Chair**	**Meteorology, Air and Precipitation Chemistry Richard Grant, Purdue University Chair**	
1320				
1340				
1400				
1420				
1440				
1500	**(break)**	**(assemble for lab tour)**	**(break)**	
1520	**Sub-Committee Meetings (continued)**	**Tour of the HAL, Mercury Analytical Lab**	**Western Regional Issues Kristi Morris, US FWS, Chair**	
1540				
1600				
1620				
1640				
1700				
1720				
1740				
1800 to 1930		**Poster Session and Reception Shaw and Fidalgo Rooms**		

NADP Technical Committee Meeting
Seattle Center, Seattle, Washington
September 10-13, 2002

TUESDAY, September 10, 2002		**Room Location**
	Registration Desk Open All Day	
7:00 a.m. to 9:00 a.m.	Executive Committee Meeting	Shaw
9:00 a.m. to 9:30 a.m.	Break	
9:30 a.m. to 9:45 a.m.	Welcome and Review Agenda - Kathy Tonnessen	Fidalgo
9:45 a.m. to 11:30 a.m.	Joint Subcommittee Meetings CAL Report HAL Report QA Report Subcommittee Agenda Topics Network Operations - Kristi Morris Data Management and Analysis - Bob Larson Environmental Effects - John Sherwell	
11:30 a.m. to 1:00 p.m.	Lunch (on your own)	
1:00 p.m. to 5:00 p.m.	Individual Subcommittee Meetings	Shaw, Fidalgo & Lopez

WEDNESDAY, September 11, 2002

7:30 a.m.	Registration	
8:00 a.m. to 10:00 a.m.	Technical Committee Annual Business Meeting Welcome and Introductions - Kathy Tonnessen Reports Executive Committee - Kathy Tonnessen Service Awards Program Advisors Regional SAES North Central - Wayne Banwart Northeast - Bruce Wiersma South - Gerald Arkin West - Don Synder CSREES - Dan Jones NTN - Mark Nilles AIRMoN - Rick Artz MDN - Clyde Sweet Program Office - Van Bowersox Subcommittees Network Operations Data Management and Analysis Environmental Effects Ad Hoc Committee for Field Chemistry - Chris Lehmann New Business Election of Officers 2003 Annual Meeting - 25th Anniversary	Lopez

WEDNESDAY, September 11 **Room Location**

10:00 a.m. - 12:00 a.m. Lopez Room

10:00 a.m. - 10:20 a.m. Break

TECHNICAL SESSION: **MERCURY EMISSIONS**
Session Chair: Robert Brunette, Frontier Geosciences, Inc.

10:20 - 10:40 ***Airborne Observations of Total Gaseous Mercury over the Eastern North Pacific***
Lawrence F. Radke and Hans R. Friedli, National Center for Atmospheric Research; Brian Heikes, University of Rhode Island

10:40 - 11:00 ***Seasonal and Diurnal Cycles of Elemental Mercury in the Marine Boundary Layer of the Pacific Northwest***
Peter Weiss and Dan Jaffe, University of Washington- Bothell; Eric Prestbo, Frontier Geosciences, Inc.

11:00 - 11:20 ***Mercury Emissions from Wildland Fires***
Hans R. Friedli and Lawrence F. Radke, National Center For Atmospheric Research

11:20 - 11:40 ***Methylated Mercury Species in Municipal Waste Landfill Gas***
E. M. Prestbo, Frontier Geosciences, Inc.; S. Lindberg and G. Southworth, Oak Ridge National Laboratory

11:40 - 12:00 ***Urban Area Influences on Wet Deposition of Mercury at MDN Sites***
Clyde W. Sweet, Illinois State Water Survey

12:00 a.m. - 1:00 p.m. Lunch (on your own)

1:00 p.m. - 3:00 p.m.

TECHNICAL SESSION: **MERCURY DEPOSITION AND EFFECTS**
Session Chair: Eric Prestbo, Frontier Geosciences, Inc.

1:00 - 1:20 ***Observations of Methyl Mercury in Precipitation: Seasonal, Spatial and Yearly Trends at Selected MDN Sites in North America***
R. C. Brunette and E. M. Prestbo, Frontier Geosciences, Inc.; C. W. Sweet, Illinois State Water Survey

1:20 - 1:40 ***Atmospheric Deposition of Mercury in South-central New Mexico, USA***
P. Swartzendruber and E. M. Prestbo, Frontier Geosciences, Inc.; C. A. Caldwell, U. S. Geological Survey

1:40 - 2:00 ***Mercury Deposition into the Casco Bay Estuary, Maine***
Steven G. Brown, Hilary H. Main, & Patrick A. Ryan, Sonoma Technology, Inc.

2:00 - 2:20 ***Monitoring Program for Atmospheric Deposition of Mercury in Indiana***
Martin R. Risch, U. S. Geological Survey

2:20 - 2:40 ***Requirements for the Establishment of Mercury Monitors in Mexico as a Pilot Project***
Anne M. Hansen and Manfred van Afferden, Instituto Mexicano de Tecnología del Agua (IMTA)

2:40 - 3:00 ***Concentrations and Interrelationships Between 20 Trace Metals in Snow Collected Along a Transect through the Western Alaskan Arctic***
N.S. Bloom, B. Brunette, and E. M. Prestbo, Frontier Geosciences, Inc.; T. A. Douglas, and M. Sturm, Cold Regions Research and Engineering Laboratory

WEDNESDAY, September 11 **Room Location**

3:00 p.m. - 5:00 p.m.

3:00 - 3:20 Assemble for Lab Tour

3:20 - 5:00 **TOUR OF THE HAL, MERCURY ANALYTICAL LABORATORY**

5:00 p.m. - 6:00 p.m. Break

6:00 p.m. - 7:30 p.m.

POSTER SESSION AND RECEPTION Shaw & Fidalgo

Twenty Five Years of Analytical Evolution. Sue Bachman and Mark Peden, Illinois State Water Survey

Next Generation Precipitation Sampler. William H. Bauman III and Mark C. Beaubien, Yankee Environmental Systems, Inc.

Atmospheric Deposition Collection Systems for General Purpose and Trace Metals Studies. John S. Beach, Jr., N–CON Systems Co., Inc.

Evaluation of Three Modern Electronic Recording Precipitation Gages. Roger D. Claybrooke, Scotty R. Dossett, and Van C. Bowersox, Illinois State Water Survey

A Closer look at National Atmospheric Deposition Split Samples. Brigita Demir and Jane Rothert, Illinois State Water Survey

Monthly and Annual Bias in Weekly (NADP/NTN) versus Daily (AIRMoN) Precipitation Chemistry Data in the Eastern U.S.A. Alice B. Gilliland, National Oceanic and Atmospheric Administration; Thomas J. Butler, Institute of Ecosystem Studies; and Gene E. Likens, Cornell University

Total and Organic Nitrogen in NADP Precipitation Samples–A Preliminary Study. Karen S. Harlin, Susan R. Bachman, and Ryan Wuebbles, Illinois State Water Survey

A Classification Scheme for NADP Sites. Robert S. Larson, Illinois State Water Survey

Evaluation of NADP Minimum Reporting Levels by Analysis of Method Detection Levels and Split Sample Data. Christopher Lehmann, Jane Rothert, and Karen Harlin, Illinois State Water Survey

Summary of Field Site Systems and Performance Survey Results for 1998-2001. Christopher Lehmann, Scott Dossett, and Mason Kessinger, Illinois State Water Survey

Investigation of Differences Between Field and Laboratory pH Measurements of NADP/NTN Precipitation Samples. Natalie Latysh and John Gordon, U. S. Geological Survey

The Importance of Dry Deposition in Coastal Regions – Hoh Rain Forest Olympic National Park. S. Anne McAfee and Robert L. Edmonds, University of Washington

Use of National Atmospheric Deposition Program Data to Develop Deposition Analysis Thresholds for Class I Area AQRV Protection. Ellen M. Porter, Fish and Wildlife Service; Tamara Blett, National Park Service

Measuring Total Nitrogen in Precipitation: A Report on the Maryland Pilot Study. John Sherwell, Maryland Department of Natural Resources; Mark Castro, University of Maryland Center for Environmental Science

Trends in the Concentration and Wet Deposition of Mercury: MDN 1995-2001. Clyde W. Sweet, Illinois State Water Survey; Robert Brunette and Eric Prestbo, Frontier Geosciences, Inc.

Phase III-Evaluation of the Ott-Pluvio Rain Gage versus the Belfort 5-780 Rain Gage for Modernizing the National Atmospheric Deposition Program. Mary L. Tumbusch, U. S. Geological Survey

THURSDAY, September 12 **Room Location**

8:00 a.m. - 9.00 a.m. Lopez

TECHNICAL SESSION: **STABLE ISOTOPIC MEASUREMENTS - A NEW APPLICATION FOR NADP SAMPLES**
Session Chair: Karen S. Harlin, Illinois State Water Survey

8:00 - 8:20 ***Spatial Patterns, Climate Phase Affects and Emerging Results in the Isotopic ($d^{18}O$ & dD) Characteristics of Precipitation Across the U. S.***
J. Welker, D. Esposito, and K. Bastian, Colorado State University; J. White and R. Vachon, University of Colorado; R. Larson, Illinois State Water Survey; A. Dutton and B. Wilkinson, University of Michigan

8:20 - 8:40 ***Stable Isotopic Composition of Nitrate in Precipitation***
Carol Kendall and Scott D. Wankel, U. S. Geological Survey

8:40 - 9:00 ***Influence of Land Derived Moisture on the Stable Isotope Composition of Precipitation***
Madhav V. Machavaram, Mark E. Conrad, and Norman L. Miller, E. O. Lawrence Berkeley National Laboratory

9:00 a.m. - 10:20 a.m.

TECHNICAL SESSION: **CHANGING GOVERNMENT POLICY - FROM CLEAN AIR TO CLEAR SKIES**
Session Chair: Gary Lear, U. S. Environmental Protection Agency

9:00 - 9:20 ***Beyond the Acid Rain Program — Assessing the Potential Achievements of the Clear Skies Act***
Richard Haeuber, U. S. Environmental Protection Agency

9:20 - 9:40 ***Environmental Accountability Under the Clear Skies Initiative: The Role of Long-Term Environmental Monitoring***
David Schmeltz, U. S. Environmental Protection Agency

9:40 - 10:00 ***Accounting for Atmospheric Deposition in a Nutrient Cap Strategy***
John Sherwell, Maryland Department of Natural Resources

10:00 - 10:20 ***Findings and Recommendations from the Second International Nitrogen Conference***
Ellis Cowling and Cari Furiness, North Carolina State University; Jan Willem Erisman, Netherlands Energy Research Foundation; James Galloway, University of Virginia

10:20 a.m. - 10:40 a.m. Break

10:40 a.m. - 12:00 p.m.

TECHNICAL SESSION: **CHANGING PRECIPITATION CHEMISTRY AND ITS EFFECTS**
Session Chair: Robert Larson, Illinois State Water Survey

10:40 - 11:00 ***20-year (1980-1999) Trends of Wet Deposition Patterns in Eastern North America***
Chul-Un Ro, Environment Canada

11:00 - 11:20 ***The Relation between NO_x Emissions and Precipitation NO_3^- in the Eastern USA***
Thomas J. Butler, Institute of Ecosystem Studies and Cornell University; Gene E. Likens, Institute of Ecosystem Studies; Francoise M. Vermeylen, Cornell University

11:20 - 11:40 ***Trends in Seasonal Variations of Total Nitrogen Deposition***
Gary Lear, U. S. Environmental Protection Agency

THURSDAY, September 12 **Room Location**

Lopez

TECHNICAL SESSION: **CHANGING PRECIPITATION CHEMISTRY AND ITS EFFECTS (CONTINUED)**

11:40 - 12:00 ***Recovery from Acid Deposition in the Adirondack and Catskill Mountains***
Michael R. McHale. and Douglas A.Burns, U. S. Geological Survey

12:00 a.m. - 1:00 p.m. Lunch (on your own)

1:00 p.m. - 3:00 p.m.

TECHNICAL SESSION: **METEOROLOGY, AIR, AND PRECIPITATION CHEMISTRY**
Session Chair: Richard Grant, Purdue University

1:00 - 1:20 ***Atmospheric Organic Nitrogen***
Cort Anastasio, Qi Zhang, John J. Carroll, and Alan Dixon, University of California

1:20 - 1:40 ***Ambient Ammonia and Ammonium Aerosol Across a Region of Variable Ammonia Emission Density***
John T. Walker, U.S. Environmental Protection Agency; Dave R Whitall, Syracuse University; Wayne Robarge, North Carolina State University; Hans W. Paerl, University of North Carolina at Chapel Hill

1:40 - 2:00 ***Empirical Evidence for the Low- and High-NOx Photochemical Regimes of Sulfate and Nitrate Formation***
Ariel F. Stein, National Oceanic and Atmospheric Administration; Dennis Lamb, Penn State University

2:00 - 2:20 ***Meteorological Indicators of Sulfur and Nitrogen Wet Deposition during Summertime in the Eastern United States***
Dennis Lamb, Penn State University; Uri Dayan, The Hebrew University of Jerusalem

2:20 - 2:40 ***Relations Between a Multivariate ENSO Index and Atmospheric Deposition Near Atlanta, Georgia, 1986-2002***
Norman E. Peters, U. S. Geological Survey; Wlodzimierz Tych, Lancaster University

2:40 - 3:00 ***Spatial Rainfall Analysis at John F. Kennedy Space Center and Cape Canaveral Air Station, FL (1989-2000)***
J. H. Drese and J. M. Rebmann, Dynamac Corporation

3:00 p.m. - 3:20 p.m. Break

3:20 p.m. - 5:20 p.m.

TECHNICAL SESSION: **WESTERN REGIONAL ISSUES**
Session Chair: Kristi Morris, U. S. Fish and Wildlife Service

3:20 - 3:40 ***Wet Deposition in National Parks of the Northwest U. S.***
Kathy Tonnessen, National Park Service; Kristi Morris, U. S. Fish & Wildlife Service

3:40 - 4:00 ***Western Airborne Contaminants Assessment Project (WACAP): Assessing Deposition and Impacts of Persistent Organic Pollutants and Metals In Six National Parks in the Western U. S.***
Tamara Blett, National Park Service

THURSDAY, September 12 **Room Location**

Lopez

TECHNICAL SESSION: **WESTERN REGIONAL ISSUES (CONTINUED)**

4:00 - 4:20 ***Modeling Ozone and Aerosol Formation and Transport in the Pacific Northwest***
Susan O'Neill, U. S. Department of Agriculture Forest Service

4:20 - 4:40 ***Air Quality Issues in the Columbia River Gorge National Scenic Area***
Bob Bachman, U. S. Department of Agriculture Forest Service

4:40 - 5:00 ***Influence of Long-Range Transport on Air Quality in the Western U. S.***
Dan Jaffe, Professor, University of Washington-Bothell

5:00 - 5:20 ***Evidence of Transport of Mongolian Dust to the Continental United States using CASTNet (Clean Air Status and Trends Network) Data***
Christopher M. Rogers, Thomas F. Lavery, and H. Kemp Howell, Harding ESE, Inc.

FRIDAY, September 13

7:30 a.m. - 4:30 p.m. Field Trip to Mount Rainier National Park

General Information

Congress established Mount Rainier National Park on March 2, 1899. It is the United State's fifth oldest National Park, after Yellowstone, Yosemite, General Grant (now part of King's Canyon) and Sequoia. The park encompasses 235,625 acres or 365 square miles. Congress designated 97% of the park as Wilderness. The park has 240 miles of maintained trails and 147 miles of roads. Each year 1.5 to 2 million people visit Mount Rainier.

Mount Rainier is 14,410 feet above sea level. It is the tallest volcano and fifth highest peak in the contiguous United States. It is a volcano that built up above the surrounding country by repeated eruptions and successive flows of lava. Mount Rainier is a relatively young volcano of about 500,000 years. By contrast the mountains of the Cascade Range that Mount Rainier looks down upon are at least 12 million years old. The last estimated eruption of Mount Rainier was between 1820 and 1884. Observers reported at least 14 eruptions some of which may have been large dust clouds caused by rockfall which were mistakenly call eruptions.

Over 34 square miles of permanent ice and snow cover Mount Rainier. Of all the glaciers in the contiguous united States, Mount Rainier Emmon's Glacier has the largest surface area of 4.3 square miles. Carbon Glacier is the longest at 5.7 miles, the thickest at 700 feet and has the lowest terminus elevation at 3,500 feet.

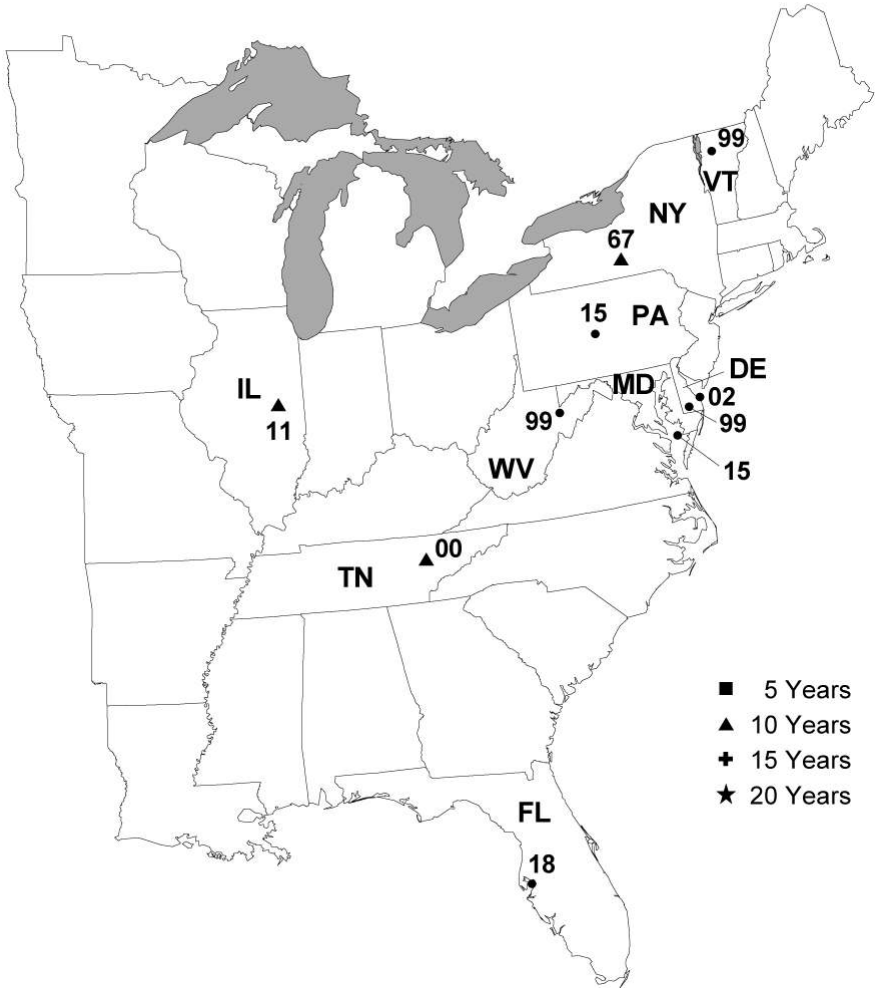
Weather & Climate

Weather patterns at Mount Rainier are strongly influenced by the Pacific Ocean, elevation, and latitude. The climate is generally cool and rainy, with summer highs in the 60s and 70s. While July and August are the sunniest months of the year, rain is possible any day, and very likely in spring, fall, and winter.

As one of the snowiest places on Earth, Paradise is worthy of a winter visit. From November to late May, expect to find 10 to 20 feet of snow on the ground. Approximately 630" of snow falls in an average winter at Paradise--in the winter of 1971-72, Paradise established a world's record with 1122" of snow!

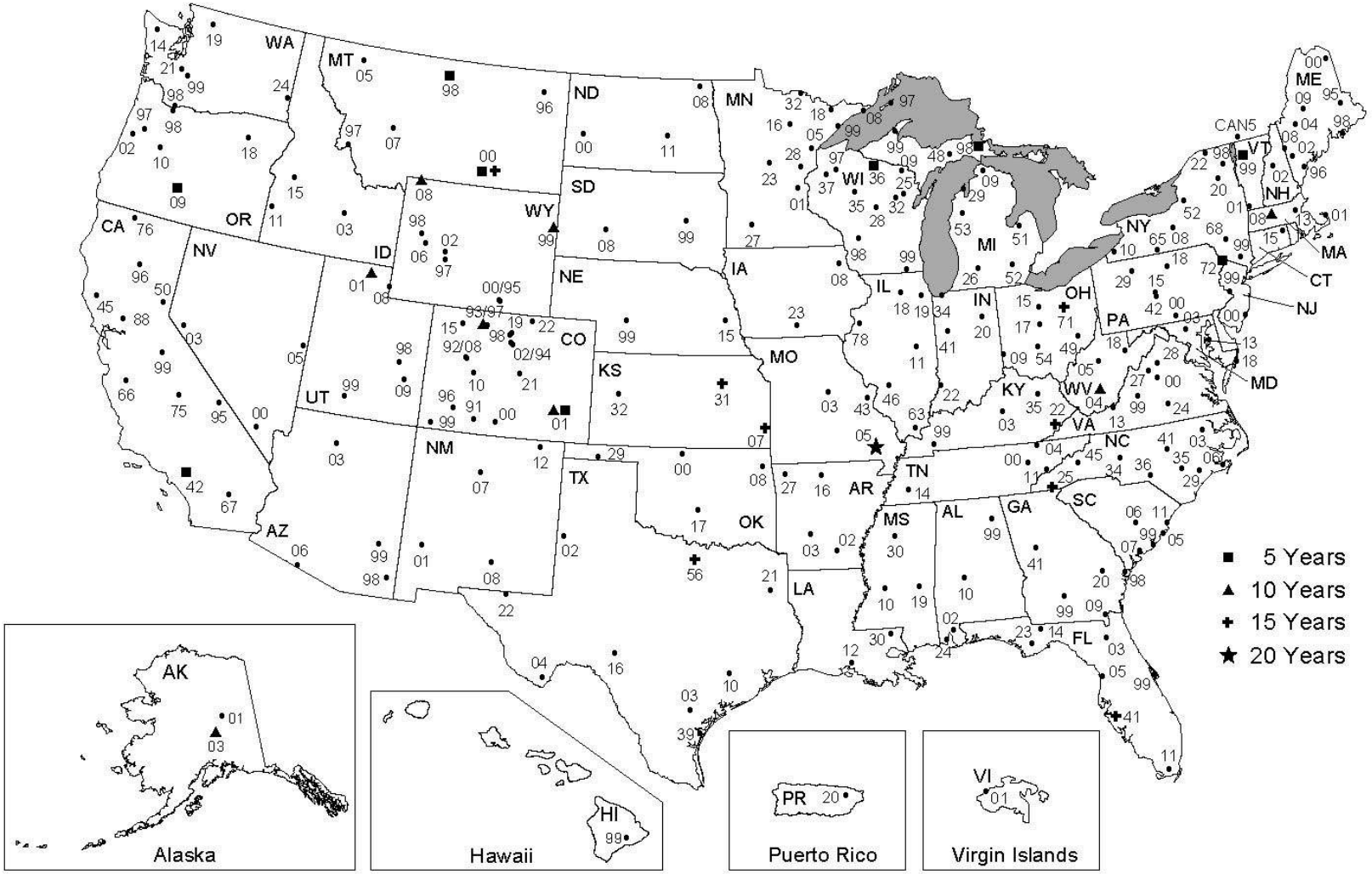
2002 NADP SITE OPERATOR AWARDS

AIRMoN Site Operator Service Awards - 2002



AIRMoN Site/Sitename	Operator Name	Wet Start	Agency
10 Year Awards			
IL11 - Bondville	Mike Snider	10/1/92	NOAA
NY67 - Ithaca	Tom Butler	9/30/92	NOAA
TN00 - Walker Branch Watershed	Ray Hosker	9/23/92	NOAA

NADP/NTN Site Operator Service Awards - 2002



NTN Site/Sitename	Operator Name	Wet Start	Agency
5 Year Awards			
CA42 - Tanbark Flat	Mike Oxford	1/12/82	USFS
CO01 - Las Animas Fish Hatchery	Nick Young	10/4/83	USGS
MI98 - Raco	Patty VerWiebe	5/1/84	EPA
MT00 - Little Big Horn Battlefield National Monument	Wayne Not Afraid	7/13/84	USGS
MT98 - Havre Experiment Station	Jeff Whitmas	7/30/85	USGS
OR09 - Silver Lake Ranger Station	Rick Elston	8/23/83	USGS
PA72 - Milford	Lynn Dennis	12/27/83	USFS
VT99 - Underhill	Miriam Pendleton	6/12/84	USGS
WI36 - Trout Lake	Barbara Reinecke	1/22/80	WI DNR
10 Year Awards			
AK03 - Denali National Park - Mt. McKinley	Andrea Blakesley	6/17/80	NPS
CO01 - Las Animas Fish Hatchery	Stan Green	10/4/83	USGS
CO93 - Dry Lake	Cap Kuney	10/14/86	USFS
MA08 - Quabbin Reservoir	Daniel Pepin	3/5/82	NESCAUM
UT01 - Logan	Zane Stephens	12/6/83	USGS
WV04 - Babcock State Park	Melvin Mathes	9/6/83	USGS
WY08 - Yellowstone National Park - Tower Falls	Colette Daigle-Berg	6/5/80	NPS
WY99 - Newcastle	Rod Randall	8/11/81	BLM
15 Year Awards			
FL41 - Verna Well Field	April Ammeson	8/25/83	USGS
KS07 - Farlington Fish Hatchery	Dan Mosier II	3/27/84	USGS
KS31 - Konza Prairie	Rosemary Ramundo	8/17/82	KSU
KY22 - Lilley Cornett Woods	Robert Watts	9/6/83	NOAA
MT00 - Little Big Horn Battlefield National Monument	Les Frickle	7/13/84	USGS
NC25 - Coweeta	Robert McCollum	7/5/78	USFS
OH71 - Wooster	Cheryl Capek	9/26/78	USGS
TX56 - L.B.J. National Grasslands	Clyde Schoultz	9/20/83	USGS
20 Year Awards			
MO05 - University Forest	Jim & Sandy Joiner	10/27/81	USGS

TECHNICAL SESSION: MERCURY EMISSIONS

Session Chair: Robert Brunette, Frontier Geosciences, Inc.

Airborne Observations of Total Gaseous Mercury over the Eastern North Pacific

*Lawrence F. Radke[1 2], Hans R. Friedli[1],
National Center for Atmospheric Research
Brian Heikes[3].
University of Rhode Island

Observations of Total Gaseous Mercury, TGM, were made aboard the NOAA WP-3 in spring of 2002 during the Intercontinental Chemical Transformation program (ITCT2K2) with a Tekran TGM analyzer modified to eliminate its known altitude dependence. The ITCT2K2 flights were based in Monterey, CA, ranged 50,000-km over the Eastern Pacific, extended as far North as the NW tip of Washington, and were primarily made in westerly flows. The troposphere was repeatedly sounded from near sea level to above 7 km. Three soundings entered the stratosphere, penetrating folds associated with a stationary cutoff low. Sampled air masses were days to weeks from known anthropogenic sources of Hg. However, given that elemental Hg, Hg (0), which comprises the great majority of TGM, is thought to have an atmospheric residence time of about 1 year our TGM observations revealed a remarkable troposphere, dominated by spatial and temporal complexity and not, well mixed, as expected. In addition to spatial complexity soundings have a pronounced vertical TGM gradient with concentrations dropping by about a factor of 5 between sea level and the tropopause. Contrarily, about 25% of the soundings do not exhibit significant altitude dependence. These observations of pronounced spatial/temporal inhomogenieties remote from known sources of TGM are incompatible with their often-quoted residence time of one year. Hence we were prompted to apply C. Junge's (1974) reasoning and theoretical determination that, a trace gas's residence time and variability should be inversely proportional, to this data set.

Junge notes that his formalism: STANDARD DEVIATION / MEAN CONCENTRATION = 0.14 / RESIDENCETIME is only valid "if the distribution of sources and sinks are similar". As we know that TGM has both geographical and seasonal inhomogenieties in sources and sinks, we believe that the 3min. resolution ITCT2K2 TGM data set, together with its long trans Pacific fetch are particularly suitable for this residence time determination. Analyzing the data by flight the TGM residence time averaged 102 days with a modest SD =23 days. Should these TGM vertical gradient and revised residence times be globally confirmed they would force major revisions in atmospheric reservoir, source and sink estimates. A similar data set was collected over the Western North Pacific off the Asian coast in spring 2001(ACE-Asia). Downwind of the continent and its sources, the ACE-Asia flight average TGM residence time averaged 12 days with a standard deviation of 3 days.

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Seasonal and Diurnal Cycles of Elemental Mercury in the Marine Boundary Layer of the Pacific Northwest

*Peter Weiss[1] [2], Dan Jaffe[1]
University of Washington-Bothell
Eric Prestbo[3]
Frontier Geosciences, Inc.

Gas-phase elemental mercury (Hg^o) has been measured continuously at the Cheeka Peak Observatory in Washington in the marine boundary layer since March 2001 and Reactive Gaseous Mercury measurements have been made since September 2001. Highest concentrations of Hg^o were observed during the spring and lowest in late fall, with a seasonal amplitude of 21% of the mean value (1.56 ng/m^3). Variability of Hg^o over the entire data set gives a Junge lifetime of about 7 months, on the low end of the most recent published estimates. Hg^o depletion was observed in all seasons during local pollution episodes that periodically influence Cheeka Peak. This depletion was strongest in the summer and when locally influenced air had enhanced CO concentrations. Estimated removal rates based on average urban Hg^o concentrations upwind of Cheeka Peak and average transport times, are on the order of days to weeks. Diurnal variability in air masses that had no contact with local sources was also large (as high as 29% peak-to peak amplitude). O_3 exhibited a strong negative correlation with Hg^o (as high as R = -0.92) during certain periods in the summer, in both polluted and clean air masses. These observations suggest a gap in the understanding of Hg^o oxidation processes that occur in marine boundary layer of the mid-latitudes, since the fastest known Hg^o reactions rates give a lifetime on the order of several months, which is not fast enough to account for our data.

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Mercury Emissions from Wildland Fires

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Mercury in plants originates from complex cycles of wet and dry deposition, evasion from soil, exchange with ambient air and in some cases from xylem sap. Upon senescence, mercury contained in needles and leaves accumulates in litter and upon decomposition in soil. A fire releases the mercury from vegetation, mostly in form of gaseous elemental and some in particulate form. Laboratory burn experiments indicated that essentially all mercury is released from vegetation and can be accounted for in the smoke. Airborne missions to fires in boreal and temperate forests revealed that more mercury is found in the plume that would be expected from vegetation alone, suggesting release from soil as well. Researchers from USGS have confirmed such releases. Average emission factors for fires in temperate forest measured in four fire complexes in Washington State during 2001 are (113+/-59) x 10^{-6} g total mercury/kg fuel burnt. The large range shows that individual fires have different character depending on fire intensity, fuel, degree of suppression and other variables. Budget estimates for fires in temperate forests in the US based on published acreage burnt and assuming 2.5 kg/m^2 fuel consumption are 2-4 metric tons per year. Boreal forests emit about 21 t/y and global estimates range as high as 500 t/y.

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Methylated Mercury Species in Municipal Waste Landfill Gas

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Mercury-bearing material has been placed in municipal landfills from a wide array of sources including fluorescent lights, batteries, electrical switches, thermometers, and general waste. The nature of landfills designed to reduce waste through generation of methane by anaerobic bacteria suggests the possibility that these systems might also serve as bioreactors for the production of methylated mercury compounds. We have quantified the concentrations of total, dimethyl and monomethyl mercury at 7 landfills in 3 separate states. Dimethyl and monomethyl forms of mercury have been quantified at maximum concentrations of 68 and 21 ng/m^3, well above ambient air concentrations. Total mercury in landfill gas has been observed at maximum levels of 10 ug/m^3. However, these initial surveys indicate that high levels of dimethyl mercury can be present when total mercury is relatively low and undetectable levels of dimethyl mercury when total mercury is very high. Naturally this suggests that specific conditions within the landfill are required to generate volatile organic-mercury species. These results identify landfills as a possible anthropogenic source of dimethyl mercury emissions to air, and may help explain the reports of monomethyl mercury in continental rainfall.

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Urban Area Influences on Wet Deposition of Mercury at MDN Sites

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From its beginning in 1995, NADP's Mercury Deposition Network (MDN) has permitted a few sites to participate even though they do not meet all of the NADP siting criteria with regard to proximity to urban centers. With the expansion of MDN to almost 70 sites over the last few years, data are now available from several urban-rural site pairs. These are sites that are located in the same region, one of which meets all NADP criteria while the other is too close to an urban area based on NADP criteria. MDN data from 6 such urban-rural pairs have been evaluated to determine whether differences in annual wet deposition of mercury and volume-weighted average mercury concentrations in precipitation can be related to urban influences. At some sites for some years, mercury concentrations are significantly higher at the urban-influenced sites. At other sites and during other years, there is no significant difference. An event-by-event analysis of the wet deposition of mercury at 2 Chicago-area sites indicates that meteorological conditions during a few key rain events each year determine how important urban influences are at a particular site.

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TECHNICAL SESSION: MERCURY DEPOSITION AND EFFECTS
Session Chair: Eric Prestbo, Frontier Geosciences, Inc.

Observations of Methyl Mercury in Precipitation: Seasonal, Spatial and Yearly Trends at Selected MDN Sites in North America

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Bloom and Watras were the first to report reliable observations of monomethyl mercury (MMHg) in precipitation in 1989. Since then, there have been some possible explanations for the source of this species of mercury in rain, but no clear consensus. Even though MMHg is nominally a small fraction (~0.1 to 5%) of the total Hg in rain, the measurement of MMHg is important because of its greater toxicity and potential importance as an indicator of atmospheric Hg chemistry. The NADP Mercury Deposition Network (MDN) has been contributing to the understanding of atmospheric organic mercury by monitoring the spatial and temporal concentrations and deposition of MMHg in rainwater. Currently there are 24 MDN sites that have made measurements of MMHg in rain. At eight MDN sites, monthly composite rain samples have been analyzed for MMHg for over 5 years. Most other participating sites measure MMHg in each weekly-integrated rainwater sample. The Upper Mid-West and Gulf-Coast States are the most well represented regions. The overall seasonal pattern for the upper Midwest sites is higher MMHg concentration and deposition during the spring and summer months, when aquatic biological uptake is greatest.

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Atmospheric Deposition of Mercury in South-central New Mexico, USA

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A Mercury Deposition Network (MDN) site (NM10) was established in south-central New Mexico to characterize mercury in precipitation of an arid landscape. Although from 1998 to 2000 NM10 had the highest volume-weighted mean concentration of total mercury (21.4 ng/L), the low rainfall rate translates into the lowest average wet-deposition rate for the entire MDN program (5.26 ug/m^2/year). Naturally, for arid ecosystem regions that receive less than 20 cm of rainfall, the atmospheric models indicate that dry deposition of mercury may be the dominant input. We have recently completed a research study at NM10 to constrain the mercury dry deposition rate. Two dry deposition methods were used: (1) direct dry deposition using an ion exchange membrane mounted on a passive horizontal collection plate to capture particulate and reactive gaseous mercury and (2) indirect dry deposition measurement by quantifying atmospheric particulate, reactive gaseous and elemental mercury and then using published deposition velocities to calculate the deposition rates for each Hg species. A description of both dry deposition methods will be presented. Based on the direct method, the average dry deposition rate of mercury was 5.8 ± 6.0 ng/m^2/h (n=15). Our estimate is within the range of previous estimates of reactive gaseous mercury dry deposition at a grassland location of 0.7 to 58 ng/m^2/hr. The average particulate and reactive gaseous mercury concentrations observed at NM10 were 3.0 ± 4.1 pg/m^3 (n=15) and 6.9 ± 7.1 pg/m^3 (n=23), respectively. The average elemental mercury concentration was 1.59 ± 0.42 ng/m^3 (n=19). The mercury speciation data will be discussed with regard to observed daily trends, calculated dry deposition rates and specific transport events.

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Mercury Deposition into the Casco Bay Estuary, Maine

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In 1990, Casco Bay was designated an "estuary of national significance" and included in the U.S. Environmental Protection Agency's (EPA) National Estuary Program. One of the main problems facing Casco Bay was elevated mercury levels in waterways, fish, and wildlife: human health can then be severely impacted by the consumption of contaminated fish. The Mercury Deposition Network (MDN) collects data at Wolfe's Neck Farm in Casco Bay, as well as at other sites within the state of Maine to enable spatial-temporal characterization of mercury deposition in the region.

Data for 1998-2001 for Casco Bay and nearby sites from MDN were used to characterize mercury deposition on a state-wide basis. A few large events were found to contribute more than 10 % of the annual mercury wet deposition. Direct air deposition accounts for most of the total mercury emissions into Casco Bay, and was highest in the spring and summer. Spatial differences between coastal and inland sites were found, and overall deposition was found to be similar to that of surrounding states.

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Monitoring Program for Atmospheric Deposition of Mercury in Indiana

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Mercury has been detected in nearly all fish tissue samples collected in Indiana since 1983. Concentrations of mercury in some fish caught from Indiana waters have prompted health officials to issue advisories about human consumption of these fish. Man-made sources of mercury emissions to the atmosphere (coal-fired power plants, municipal incinerators, industrial boilers) have been implicated for causing much of the mercury found in fish. Previously, only limited information was available about the atmospheric contribution of mercury to Indiana's aquatic ecosystems. Starting in 2001, the U.S. Geological Survey, in cooperation with the Indiana Department of Environmental Management, established and operates a monitoring program for atmospheric deposition of mercury in Indiana. Coordinated through the Indiana Mercury Work Group, it is one of several initiatives to measure and reduce mercury in Indiana's environment. Four monitoring stations are being operated as part of the Mercury Deposition Network of the National Atmospheric Deposition Program. These stations were strategically located in the state, based on potential mercury sources and weather patterns. During 2001, weekly precipitation samples were analyzed for total mercury and methylmercury. This presentation describes the rationale of the Indiana network and presents results of the monitoring during 2001.

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Requirements for the Establishment of Mercury Monitors in Mexico as a Pilot Project

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The Mercury Deposition Network (MDN) is evaluating the possibility to extend its coverage, by installing two sites in Mexico. The North American Commission for Environmental Cooperation (NACEC) has assigned funds to assess the perspective of such an initiative. The general objective is to identify the requirements for installation of two mercury monitors in Mexico as a pilot project in collaboration with key agencies in Mexico and liaising with appropriate Canadian and US authorities as well as private sector contractors. This will allow to integrate Mexican sampling stations in the existing network and further collaboration in prevention of exposure. The potential sites for mercury wet deposition should be located far from mercury point sources (Acosta y Asociados 2001) in order to measure background levels. Among the first selection criteria, the location of these sites on or close to the automatic hydroclimatological stations (AHSs) or meteorological observatories (MOs) was included. The application of the regional requirements (Bigelow *et al.* 2001) to 142 AHSs and MOs resulted in the exclusion of 108. The outcome of the following application of specific Mexican, local, and on-site requirements (accessibility by ground, infrastructure such as courier mail service, electricity, telephone, laboratory, and that a potential operator should live on or very close to the site, resulted in ten preselected sites from which only four have a chemical laboratory close by. Among these four sites, two adapted most to the NADP criteria: Huejutla and Puerto Ángel.

Location and rainfall at the selected sites

Site Name	Huejutla	**Puerto Ángel**
Location	Instituto Tecnológico Agropecuario No. 6	Radar station
City	Huejutla	Puerto Ángel
State	Hidalgo	Oaxaca
Latitude	21º 09' 30" N	15˚40'16" N
Longitude	98º 22' 14" W	96˚29'50" W
Elevation	180 mamsl	110 mamsl
Annual precipitation	1,312 mm	800-1,000 mm

The costs of the project for a duration of two years was estimated. Considering that the equipments (raingage and mercury sampler) will be borrowed by NADP over a two-year period and that mercury analysis will be performed by Frontier Geosciences, a cost of $186,400 US was estimated. This estimation includes the costs for installation, operation, capacity building, analysis of mercury species and major ions, and project management. The project coordination will be in charge of a steering committee, where NADP (National Atmospheric Deposition Program), NIE (National Institute for Ecology), NACEC (Mercury, M&A Task Forces) will participate. The technical project coordination will be carried out by IMTA. Equipment and analysis will be donated by NADP and Frontier Geosciences, among others. On-site institutions that will participate in the project are the SMN-CNA (National Meteorological Service, National Water Commission) in Puerto Ángel and Huejutla, Hgo., Mexico, as well as the Instituto Tecnológico Agropecuario No. 6.

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Concentrations and Interrelationships Between 20 Trace Metals in Snow Collected Along a Transect through the Western Alaskan Arctic

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Snow was collected for trace metals analysis at 5 locations between Nome and Barrow (Alaska). Samples were collected in triplicate, and each was separated into three depth intervals. Snow was collected directly into HF/HNO_3 cleaned Teflon bottles using the ultra-clean technique, and stored frozen from the time of collection until preservation at the laboratory. Samples for Hg were preserved with 1% of a 0.2N BrCl solution and analyzed by CVAFS. Samples for other trace metals were preserved with 0.9% HNO_3 + 0.1% HF, a 100 mL aliquot evapo-concentrated to 10.0 mL at 95°C in Teflon beakers in a class-100 clean station, and then analyzed by ICP/MS. Our results yield MDLs in the low ng/L range for elements not previously reported for Alaskan snow, which is necessary because many of the trace are present at low but detectable levels (Cd, 1-19 ng/L; Pb, 32-596 ng/L, and Hg, 0.8-6.2 ng/L). Trace metals were clustered in four correlation groups which could be suggestive of their origination: (1) Na, Mg, Sr, and Hg; (2) Al, Fe, Be, V, Cr, Mo, Sb, Ba, Mn, Co, Ni, Cu, As, Ag, Tl and U; (3) Cd, As, Sb, Tl and Pb; (4) Zn and Ca (uncorrelated elements).

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TECHNICAL SESSION: STABLE ISOTOPIC MEASUREMENTS- A NEW APPLICATION FOR NADP SAMPLES

Session Chair: Karen Harlin, Illinois State Water Survey

Spatial Patterns, Climate Phase Affects and Emerging Results in the Isotopic ($\delta^{18}O$ & δD) Characteristics of Precipitation Across the U. S.

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We have used NADP samples for a spatial analysis of the $\delta^{18}O$ & δD in precipitation. After analyzing samples from across the country for the years 1989, 1990, 1991, 1992 & 1993 we have found: 1) The most depleted precipitation in the U. S. occurs over the Northern Rocky Mountain Region, 2) the most enriched precipitation occurs in S. Florida, 3) the spatial patterns of $\delta^{18}O$ in precipitation during El Nino and La Nina climate phases are different especially in the desert SW, 4) the temperature-$\delta^{18}O$ relationships are different in El Nino and La Nina phases, 5) the altitude affects on the $\delta^{18}O$ in precipitation are different between the two climate phases, 5) the $\delta^{18}O$ in river water is slightly depleted compared to that of precipitation for the W. U. S. and slightly enriched for portions of the central Great Plains, & 6) the $\delta^{18}O$-values of daily precipitation (AIRMon) are highly correlated with the temperature at the time of observation at some sites but not all.

Stable Isotopic Composition of Nitrate in Precipitation

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Nitrate in rain, throughfall, and snow has been analyzed for both $\delta^{18}O$ and $\delta^{15}N$ from over a dozen sites worldwide in the last decade since methods for analyzing nitrate for $\delta^{18}O$ first became available. Recently, methods have been developed to analyze nitrate for $\delta^{17}O$, as an additional tracer of nitrate sources and recycling mechanisms. A recent survey of available data suggests that there is considerable evidence that atmospheric nitrate has distinctive $\delta^{18}O$ and $\delta^{17}O$ signatures relative to terrestrial sources of nitrate. Furthermore, there is increasing anecdotal evidence that different anthropogenic sources of atmospheric nitrate may have distinctive isotopic signatures. This presentation will summarize existing precipitation isotope data and describe a recently initiated pilot study that uses archived NADP samples to assess the spatial and temporal variability in nitrate isotopes in wet and dry deposition across the USA.

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Influence of Land Derived Moisture on the Stable Isotope Composition of Precipitation

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The most dynamic changes in the water cycle occur in the atmospheric part of the cycle via moisture transport, precipitation and evapo-transpiration. The precipitation in any given region is significantly influenced by the locally derived moisture through evaporation from surface water bodies and soils and transpiration from vegetation. It is important to quantify the regional contribution of these various moisture sources to the water cycle to gain a more comprehensive understanding of the water cycling on a global scale. Variations in the stable isotopic composition (δD, $\delta^{18}O$) of rainfall are one possible indicator of the role of locally derived water vapor on the regional water cycle.

As part of an initiative to evaluate the influence of locally-derived water vapor on the water cycle, samples for isotopic analysis are being collected on a quarterly basis from streams, lakes, groundwater, soil moisture and atmospheric vapor from the Whitewater drainage basin in Kansas. Additionally, the isotopic composition of precipitation samples collected by the National Atmospheric Deposition Program (NADP) are also being analyzed to understand the isotopic evolution of Gulf moisture fluxes during their transect across the Great Plains region. Preliminary results indicate a general increase in the excess deuterium in precipitation (indicating admixture of evapotranspired moisture to the source moisture flux) as the storms move from the Gulf in to the Great Plains.

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TECHNICAL SESSION: **CHANGING GOVERNMENT POLICY - FROM CLEAN AIR TO CLEAR SKIES**

Session Chair: Gary Lear, U. S. Environmental Protection Agency

Beyond the Acid Rain Program — Assessing the Potential Achievements of the Clear Skies Act

Richard Haeuber
U. S. Environmental Protection Agency[1]

The new millennium marked the ten year anniversary of the creation of Title IV and the completion of the first phase of the Acid Rain Program (1995-1999). Various recent workshops, analyses, and government reports used the completion of Title IV Phase I and implementation of Phase II as an opportunity to assess whether the emission reductions goals and programs established under Title IV (both Phase I and II) are sufficient to achieve the environmental and human health objectives envisioned by Congress and the public in 1990. Recent questioning of the sufficiency of Title IV also spawned various legislative proposals for further emission reductions. The Clear Skies Act is a recently introduced legislative proposal designed to reduce and cap emissions of SO_2, NO_X, and mercury from the power generation sector. This presentation examines the projected results of the Clear Skies Act in relation to full implementation of current Clean Air Act programs with regard to SO_2, NO_X, and mercury emissions; deposition of sulfur, nitrogen, and mercury; particulate matter concentrations and visibility; and attainment of the new PM 2.5 and ozone air quality standards.

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Environmental Accountability Under the Clear Skies Initiative: The Role of Long-Term Environmental Monitoring

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The Clear Skies Initiative is a multi-pollutant control plan that seeks to reduce emissions of sulfur dioxide, nitrogen oxide, and mercury from power plants 70% from current emissions levels. As an important element of the Initiative, and more recently in the proposed legislation, long-term environmental monitoring networks are prominently featured as mechanisms for demonstrating the efficacy of the planned emission reductions. Clear Skies promotes the development of a robust national environmental monitoring capacity that can routinely provide data to characterize deposition levels and identify relationships among emissions, atmospheric loadings, and effects on human health and the environment. EPA's experiences implementing and evaluating the Acid Rain Program provide a model of accountability from which Clear Skies is based. Under the Acid Rain Program, measurement data from NADP, CASTNET, and TIME/LTM in particular, have been widely used by scientists and policymakers to track progress in reducing emissions over time and space. Similarly, under Clear Skies, these long-term monitoring networks will play a critical role in assessing progress in reducing emissions over broad regions of the U.S.

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Accounting for Atmospheric Deposition in a Nutrient Cap Strategy

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Excess levels of nitrogen and phosphorus are the primary pollutants affecting the water quality of the Chesapeake Bay. The Chesapeake Bay Agreement set the goal to reduce levels of nitrogen and phosphorus by 40 percent by the year 2000 and maintain that reduction thereafter. Hence a nutrient cap is set. Atmospheric deposition has been recognized as a significant source of nutrient nitrogen to the Chesapeake Bay, accounting for about one quarter of the total nitrogen load in the Bay waters. The Clean Air Act Amendments of 1990 requires a broad range of sources within the Bay airshed to reduce their NOx emissions, principally for ozone nonattainment reasons. The collateral benefit of reduced nitrogen deposition can be obtained. While these reductions are helpful they do not substantially reduce the atmospheric contribution to the nutrient load. This paper reports the expected extent of the CAA benefits, and discusses additional approaches that jurisdictions may take to further to reduce impacts from atmospheric deposition. Issues of source apportionment and the allocation of credit for load reductions are also addressed.

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Findings and Recommendations from the Second International Nitrogen Conference

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Human efforts to produce food and energy are changing the nitrogen cycle of the Earth. Many of these changes are highly beneficial for humans, while others are detrimental to people and the environment. These changes transcend scientific disciplines, geographical boundaries, and political structures. They challenge the creative minds of natural scientists, economists, engineers, business leaders, and decision makers. The *Second International Nitrogen Conference: Optimizing Nitrogen Management in Food and Energy Production and Environmental Protection* was designed to facilitate communications among all stakeholders in the "nitrogen community" of the world. Several recommendations emerged from the conference:

- Focus new research on options that will reuse or remove reactive nitrogen (Nr) before it cascades through the environment.
- Strengthen incentives for environmental stewardship.
- Develop multi-pollutant multi-effect strategies to optimally combat environmental effects resulting from human activities.
- Make firm commitments to long-term monitoring programs.
- Increase scientific knowledge of the fate, flows, denitrification rates, and residence time of Nr in various parts of the nitrogen cascade.
- Develop integrated research approaches that address Nr issues in the context of linkages with other nutrient cycles, especially carbon, sulfur, and phosphorus.
- Establish a quasi-permanent international research and/or research and policy assessment program.

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TECHNICAL SESSION: **CHANGING PRECIPITATION CHEMISTRY AND ITS EFFECTS**
Session Chair: Robert Larson, Illinois State Water Survey

20-year (1980-1999) Trends of Wet Deposition Patterns In Eastern North America

Chul-Un Ro
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Since the late 1970s, the Meteorological Service of Canada (MSC) has measured ion concentrations in precipitation across Canada. In the early 1980s, provincial networks began sampling in eastern Canada. In 1987, MSC developed the National Atmospheric Chemistry (NAtChem) Database to combine federal, provincial and US precipitation chemistry data for spatial analysis.

With more than 20 years of measurements in the NAtChem archive, it is now possible to extract with some confidence the long-term trends in the data. This study focuses on changes to North American long-term average concentration and deposition patterns of $nssSO_4^{=}$, NO_3^-, pH, H^+, NH_4^+, Ca^{++}, Mg^{++} and K^+.

The characteristic spatial pattern of $nssSO_4^{=}$, NO_3^-, pH, H^+ represents a mis-shapen bullseye, with the centre located in the lower Great Lakes area. The patterns of NH_4^+ and Ca^{++} show high values in agricultural areas. Maximum values of Mg^{++} occur in the areas of the strong influences of sea-salt and agricultural activity. Highest values of K^+ occur along the eastern seaboard reflecting the influence of sea salt.

Changes to the North American spatial patterns of $nssSO_4^{=}$, NO_3^- and pH will be presented to determine the Canada/US impact of SO_2 emission reductions in the five years before and after the implementation of the Clean Air Act Amendment Phase 1 reductions in 1995.

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The Relation between NO_x Emissions and Precipitation NO_3^- in the Eastern USA

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In the 1990's, NO_x emission decreases in the non-vehicle sectors have been largely offset by increases in the vehicle sector. In order to quantify the impact of NO_x emissions on precipitation NO_3^-, we used a random coefficient model, based on annual regional NO_x emissions regressed on precipitation NO_3^- concentrations from 24 NADP/NTN and NADP/AIRMoN precipitation chemistry sites in the northeastern and mid-Atlantic regions of the USA. These are areas where the total NO_x, and non-vehicle NO_x emissions have declined 9% and 23% respectively from 1991 to 2000. Electric utility NO_x emissions, part of the non-vehicle sectors, have declined 33% in this area.

A simple linear regression random coefficient model of precipitation NO_3^- and total NO_x emissions (based on 9-hr back trajectories) shows a highly significant (P-value < 0.0001) relation. Using this model, a 50% decline in total NO_x emissions predicts an overall decline in precipitation NO_3^- concentration of 44% (s.e. $\pm$ 7%). A better model fit is obtained if non-vehicle NO_x emissions is the independent variable. Based on year 2000 NO_x emissions and NO_3^- concentration data the model predicts that a 50% decline in non-vehicle emissions, which is a 23% decline in total emissions impacting the area, results in a 19% (s.e. $\pm$ 3%) decline in precipitation NO_3^- concentration. Reductions in NO_x emissions should reduce NO_3^- concentrations (and deposition) with an efficiency of 80% to 90%. Thus, both models demonstrate comparable reductions in precipitation NO_3^- with reduced NO_x emissions. It can be inferred that equivalent reductions (in terms of µeq/l) in precipitation acidity will also occur.

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Trends in Seasonal Variations of Total Nitrogen Deposition

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Atmospheric deposition of nitrogen can be sequestered by plant growth or be leached out of the soil, depending on the time of year of the deposition and the procession of seasonal plant growth for the area. Degradation of ground and surface water quality can be exacerbated for those areas where leaching and percolation are the predominant fates of nitrogen. On a national-scale, it has previously been shown no significant trends in nitrogen deposition from 1990 to 2001. However, on a smaller scale, several areas of the country have seen significant increases in nitrogen deposition. This presentation will describe regional, long-term trends in annual and seasonal total nitrogen deposition.

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Recovery from Acid Deposition in the Adirondack and Catskill Mountains

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Trends in acid deposition and surface water chemistry were calculated for sites within the Adirondack and Catskill Mountains using Seasonal Kendall Trend analyses. Trends in acid deposition were calculated from the early 1980s to 2001 at six National Atmospheric Deposition Program (NADP) stations; three in the Adirondack Mountains and three in or near the Catskill Mountains. There was a significant positive trend of 0.01 pH units year^{-1} for all sites. For nitrate (NO_3^-) there was a significant negative trend of 0.01 to 0.02 mg L^{-1} year^{-1} for all sites except Whiteface Mountain in the Adirondacks and Biscuit Brook in the Catskills. Sulfate (SO_4^{2-}) showed a decreasing trend in concentration of 0.05 to 0.06 mg L^{-1} year^{-1} at all sites. There were no trends in base cation concentrations (calcium, potassium, sodium, and magnesium).

From 1991 to 2001 there were no significant trends in precipitation chemistry at any of the sites for pH, NO_3^-, SO_4^{2-}, or base cations. During that same period there were negative trends in surface water sulfate concentrations at 12 Adirondack Long-Term Monitoring (ALTM) lakes that ranged from 0.013 to 0.19 mg L^{-1} year^{-1} and were 0.12 mg L^{-1} year^{-1} or greater at ten of the sites. At four long-term stream monitoring sites within the Catskill Mountains trends in sulfate concentration were within the same range as those in the Adirondacks. For NO_3^-, significant negative trends in concentration were detected at only five of the Adirondack sites (ranging from 0.02 to 0.06 mg L^{-1} year^{-1}) and at one of the Catskill sites (0.06 mg L^{-1} year^{-1}). Although there were no trends in calcium concentration at any of the deposition sites, there was a small positive trend at one of the Catskill stream sites (Neversink River at Claryville, 0.03 mg L^{-1} year^{-1}) and a small negative trend at another Catskill stream site (Biscuit Brook) of 0.04 mg L^{-1} year^{-1}. In the Adirondacks, there were small negative trends in calcium concentration at all sites ranging from 0.004 to 0.06 mg L^{-1} year^{-1}. Stream pH trends in the Catskills ranged from –0.16 at Biscuit Brook to +0.02 pH units year^{-1} at Neversink River at Claryville. Otter Lake was the only Adirondack site that showed a trend in pH (+0.1 pH units year^{-1}).

The presence of significant trends in precipitation chemistry from the early 1980s to 2001, but their absence during the last ten years, during the period of surface water record, may indicate a lag between changes atmospheric deposition and that measured in surface water. The rates of decreasing surface water NO_3^- and SO_4^{2-} concentrations are similar, albeit small, in the Adirondack and Catskill Mountains. Nonetheless, it may be premature to suggest that these waters are recovering from acid deposition since the changes in surface water chemistry have resulted in significantly increasing trends in pH at only one site in the Adirondacks and two sites in the Catskills.
$\delta^{18}O$

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TECHNICAL SESSION: METEOROLOGY, AIR, AND PRECIPITATION CHEMISTRY
Session Chair: Richard Grant, Purdue University

Atmospheric Organic Nitrogen

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Department of Land, Air & Water Resources

A few past studies have shown that there can be significant amounts of organic nitrogen (ON) in wet and dry deposition and that a significant portion of this ON is biologically available. However, there is little information on the concentrations or composition of atmospheric organic nitrogen in California, and even less is known of the fate of ON in the atmosphere. To examine these issues we have measured concentrations of atmospheric inorganic and organic N in Davis, CA and in the Lake Tahoe Basin. Results from fine particles and fog waters at Davis reveal that ON typically accounts for ~ 20% of total N and that amino compounds account for ~ 20% of the organic nitrogen. Aircraft measurements at Lake Tahoe show that organic forms account for a widely varying fraction (~ 10 – 60%) of the total gaseous and particulate N. We have also performed a number of laboratory studies to examine whether ON is transformed in the atmosphere. Experiments with Davis fog waters and aerosol particles reveal that a large fraction of organic N can be converted to inorganic forms, including nitrate and ammonium, during illumination with sunlight.

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Ambient Ammonia and Ammonium Aerosol Across a Region of Variable Ammonia Emission Density

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We present 1 year of ambient ammonia (NH_3), ammonium (NH_4^+), hydrochloric acid (HCl), chloride (Cl^-), nitric acid (HNO_3), nitrate (NO_3^-), nitrous acid (HONO), sulfur dioxide (SO_2), and sulfate ($SO_4^=$) concentrations at three sites in the Coastal Plain region of North Carolina. County-scale total NH_3 emission densities for the sites ranged from 320 kg NH_3-N km^{-2} yr^{-1} at a coastal site at Morehead City to 4800 kg NH_3-N km^{-2} yr^{-1} inland at Clinton, while another inland site at Kinston had a corresponding emission density of approximately 2280 kg NH_3-N km^{-2} yr^{-1}. Average NH_3 concentrations were 5.32, 2.46, and 0.58 µg m^{-3} at Clinton, Kinston, and Morehead City, respectively. Average NH_4^+ concentrations were 1.84, 1.25, and 0.91 µg m^{-3}, and total concentrations of NH_4^+-based ($NH_4^+ + NO_3^- + SO_4^= + Cl^-$) particulate matter with aerosol diameters < 2.5 µm ($PM_{2.5}$) were 8.66, 6.35, and 5.31 µg m^{-3} at Clinton, Kinston, and Morehead City, respectively. NH_3 concentrations were highest during the summer at all sites, with summer-to-winter concentration ratios of 2.40, 5.70, and 1.70 at Clinton, Kinston, and Morehead City, respectively. NH_3 concentrations were higher at night at the Clinton site, during the day at the Kinston site, and day vs. night concentrations were similar at the Morehead City site. NH_4^+ concentrations were highest during the winter at all sites, though this may not be representative of all years. Average daytime concentrations of NH_4^+ were similar to night values at all sites. NH_4^+ aerosol was primarily associated with $SO_4^=$ at all sites, though the degree of $SO_4^=$ neutralization was highest at Clinton and lowest at Morehead City. NH_4^+ aerosol formation appeared to be acid-gas-limited at the Clinton site during all seasons and during the spring and summer at the Kinston site. NH_4^+ aerosol formation was NH_3-limited during all seasons at the Morehead City site and during the winter and fall at the Kinston site. This study shows that agricultural NH_3 emissions influence local ambient concentrations of NH_3 and $PM_{2.5}$.

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Empirical Evidence for the Low- and High-NOx Photochemical Regimes of Sulfate and Nitrate Formation

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The formation of sulfate and nitrate in eastern North America is chemically linked to the abundance of oxidants and therefore to the emissions of nitrogen oxides (NOx). Depending on conditions, NOx reacts under either of two distinct photochemical regimes, defined by the types and levels of radical production. In the low-NOx regime, nitrogen dioxide (NO_2) is removed slowly by the formation of nitric acid, leaving an excess of radicals that recombine to form peroxides and a highly oxidizing state favorable to sulfate formation. On the other hand, under high-NOx conditions, the oxidizing capacity of the atmosphere is reduced because the NO_2 combines rapidly with hydroxyl radicals, producing high levels of nitric acid, but few peroxides. The distinctions between these two chemical regimes are crucial for interpreting atmospheric deposition data because they determine whether sulfate or nitrate is the dominant acidifying component. Evidence for these regimes is gained from two case studies. The first case is a modeling study of the summertime formation of aerosol sulfate and nitrate, whereas the second case involves data from a rural site. Both case studies feature the very same intrinsic chemical behavior as expected theoretically of the high- and low-NOx chemical regimes.

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Meteorological Indicators of Sulfur and Nitrogen Wet Deposition during Summertime in the Eastern United States

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The wet deposition of anthropogenic pollutants that arises from individual storms at any given site is determined by a complicated blend of chemical and meteorological factors. Sulfur compounds, for instance, are deposited preferentially during summertime across central Pennsylvania because strong oxidants are plentiful then for transforming sulfur dioxide to sulfuric acid. Variability within a given season, however, may be driven primarily by the day-to-day weather patterns that cause air to move across regions of greater or lesser source strength. The goal of this study was to exam the role of meteorology in determining the intra-seasonal variations in the concentrations of key sulfur and nitrogen compounds (sulfate, nitrate, and ammonia) at the Penn State (PA15) AIRMoN site. A combination of objective and subjective methods was used to classify the daily precipitation chemistry data for nine consecutive summers (1993-2001) into key synoptic circulation types. Significant differences in acidity and analyte concentrations were found among the seven storm types. The Convective type had the highest mean concentrations for all major ions compared to the Warm-Front type, which featured the lowest concentrations. Success in relating atmospheric deposition to specific weather patterns may one day lead to predictive capabilities.

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Relations Between a Multivariate ENSO Index and Atmospheric Deposition Near Atlanta, Georgia, 1986-2002

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U. S. Geological Survey
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Lancaster University

Wet atmospheric deposition was investigated from weekly wet-only samples at the Panola Mountain Research Watershed (PMRW), a forested research site 25 km, southeast of Atlanta, Georgia. The deposition was evaluated with respect to a monthly Multivariate El Niño/Southern Oscillation (ENSO) Index (MEI) to determine what effect ENSO events have on atmospheric deposition at PMRW. In addition, the daily precipitation-quantity time-series was investigated to evaluate patterns in the timing of rainfall, and the inter-annual relation among spectra, constituent deposition, and MEI. The Cl, NH_4, Ca, and NH_4–plus–NO_3 annual deposition are negatively correlated with the annual monthly minimum MEI. Although the annual MEI patterns are more indicative of El Niño or La Niña, the more negative the values in a given year, the more likely that there is a La Niña event; and the more positive the more likely an El Niño event. A general change in atmospheric circulation due to ENSO may change contributions of agricultural sources (a likely source of these constituents), which are predominantly to the south and southwest of PMRW, to deposition of these constituents at PMRW. The deposition correlations suggest that years with the highest deposition may be more closely associated with El Niño events and *vice versa*. Also, an analysis of the precipitation time series indicates that rainfall occurs with a frequency of 15, 6.7 and 3.3 days, but that these patterns differ from year to year and also may be associated with ENSO events.

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Spatial Rainfall Analysis at John F. Kennedy Space Center and Cape Canaveral Air Station, Fl. (1989-2000)

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This paper presents a spatial-temporal analysis of ten years of rainfall data collected at Kennedy Space Center, FL. from 1989 through 2000. The data are from 16 Tropical Rainfall Measuring Mission (TRMM) ground validation sites, the National Acid Deposition Program (NADP) site (FL99), the Shuttle Landing Facility (SLF) site, and the City of Titusville site. Analysis showed that the 1980's were drier than the 1990's. The period from 1984 through 1988, 1996, and 1997 was dropped from the scope of this paper because only the NADP data were available. The year 1992 was the most "normal" of the period from 1989 through 2000, with the least deviations from the 10-year mean on a monthly basis. A temporal analysis on the years 1989, 1991, 1992, and 1998 to showed that there were differences from year to year due to the types of storms which occurred (i.e., convective or frontal). A spatial analysis using a composite year (1989-1995 & 1998-2000) using Arcview Spatial Analyst tool showed a distinct North to South and East to West driest to wettest pattern. The year 1993 was excluded since it was an extreme drought year and 1994 and 1995 were excluded because of the "storm of the Century" and two hurricanes (i.e. extreme events). Spatial patterns for the years 1989, 1991, 1992, and 1998 were discussed individually and in comparison with the composite year analysis previously mentioned. The spatial differences (driest to wettest) were as follows: 1989: 53.39 cm, 1991: 75.52 cm, 1992: 42.90 cm, and 1998: 54.16 cm. It is evident that the use of a single station (i.e., SLF or NADP) to represent the climate of all of KSC, or any similar size area or major city is not sufficient.

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TECHNICAL SESSION: WESTERN REGIONAL ISSUES

Session Chair: Kristi Morris, U. S. Fish and Wildlife Service, Air Quality Branch

Wet Deposition in National Parks of the Northwest U.S.

*Kathy Tonnessen[1]
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Wet deposition has been measured by the National Atmospheric Deposition Program at several National Park Service (NPS) units in the Northwest, including Mount Rainier, North Cascades, Olympic, and Glacier National Parks. All of these sites have been in operation since at least 1984. Annual mean sulfate deposition for these sites from 1985 to 2001 ranged from 2.5 to 8 kg ha^{-1}, with Olympic having the highest and Glacier having the lowest value. Mean inorganic nitrogen deposition for the sites was approximately 1 kg ha^{-1} yr^{-1}, with the exception of North Cascades that had almost double that amount. Trend analyses of precipitation chemistry indicate that from 1981-1998 sulfate concentrations declined at Olympic and North Cascades National Parks. However, concentrations of nitrate increased during that same period at Olympic, North Cascades, and Mount Rainier; and concentrations of ammonium increased at Olympic and North Cascades. Deposition data at these parks are compiled and used by the NPS Inventory and Monitoring Program and the Park Research and Intensive Monitoring of Ecosystems Network (PRIMENet).

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Western Airborne Contaminants Assessment Project (WACAP): Assessing Deposition and Impacts of Persistent Organic Pollutants and Metals In Six National Parks in the Western U.S.

Tamara Blett[1]
National Park Service

NPS has initiated the a "Western Airborne Contaminants Assessment Project" (WACAP) to determine the risk to ecosystems and food webs in western national parks from airborne contaminants. The objective of the five year project is to inventory airborne contaminants in national park ecosystems using a network of sites in parks of the western U.S. to provide spatially extensive, site specific, and temporally resolved information regarding the exposure, accumulation, and impacts of airborne toxic compounds. NPS is concerned about airborne contaminants because they can pose serious health threats to wildlife and humans, as some of these compounds tend to "biomagnify" in the food chain. Biological effects of airborne contaminants include impacts on reproductive success, growth, behavior, disease, and survival. Inventories of contaminants from six ecosystem components (snow, water, sediment, lichen, bark, and fish will be conducted in six key parks in the West and Alaska. Contaminant concentrations in wild foods consumed by subsistence-users will also be assessed in Alaska. EPA, USGS, and several universities are working with the NPS on this assessment.

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Modeling Ozone and Aerosol Formation and Transport in the Pacific Northwest

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U. S. Department of Agriculture Forest Service

The Pacific Northwest is unique because it is home to heavily urbanized areas situated in a domain dominated by forests, mountains, and agricultural areas. The region suffers from two major air quality problems: ozone and aerosol formation and transport. Ozone is a secondary pollutant, the chief component of photochemical smog, and can adversely affect human health and damage plant life and ecosystems. Aerosols are both directly emitted into the atmosphere and created as secondary pollutants via complex reactions of long-chain hydrocarbons with the OH radical, or O3 and NO3 at night. Aerosols with aerodynamic diameters less than 2.5 micrometers (PM2.5) have been linked both with adverse health effects and visibility degradation. Presented here are the results of two air quality modeling studies. The first study compares ozone results from the Community Multi-scale Air Quality (CMAQ) modeling system and the CALGRID modeling system with ozone monitoring data from 12 stations located along the Interstate-5 corridor of Oregon and Washington. This study is unique because it employs process analysis, which tracks the relative contribution each process (such as advection, deposition, and chemical transformation) makes to the specie conservation equation. Results indicate that the models arrive at similar results by very different means. The second study presents CMAQ modeling results of aerosol concentrations across the Pacific Northwest compared with twelve Interagency Monitoring of PROtected Visual Envrionments (IMPROVE) monitor results located in Class I wilderness areas.

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Air Quality Issues in the Columbia River Gorge National Scenic Area

Bob Bachman[1]
U. S. Department of Agriculture Forest Service

Air quality monitoring in the Columbia River Gorge National Scenic Area over the past ten years has revealed a relatively high frequency of visibility impairment and ecosystem disturbance associated with air pollution. This information has been derived from two Interagency Monitoring of Protected Visual Environments (IMPROVE) regional haze sites, and from a regional grid of lichen sampling plot information compared with NADP wet deposition data.

Visibility impairment associated with fine particulate sulfur, nitrogen, organics, carbon and soil occurs 95% of the time –moderate impairment 50% and severe impairment 15% of the time.

Lichen community sampling and lichen tissue chemistry analysis has similarly shown relatively high concentrations of sulfur, nitrogen, and metals compared to the cleaner adjacent National Forest System (NFS) lands. The populations of endemic lichen species with known sulfur sensitivity are very low to completely absent. The populations of invasive weedy lichen species with an affinity for nitrogen are relatively high. Statistical relationships between S and N lichen tissue chemistry and National Acid Deposition program wet deposition chemistry from the eleven sites in the Pacific Northwest similarly shows relatively high (on the order of 10kg/ha/yr) S and N deposition compared to the surrounding NFS lands.

Relating this monitoring information to regional geographic features and seasonal meteorological information leads one to some interesting and from a regulatory perspective perplexing conclusions.

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Influence of Long-Range Transport on Air Quality in the Western U.S.

Dan Jaffe, Professor[1]
University of Washington-Bothell

In 1997, we first detected air pollution at the Cheeka Peak Observatory in Washington State, which had been transported from the Eurasian continent in about 6 days time. Based on ground and airborne observations since then, we now know that this transport is a regular occurrence. This largely reflects the prevalence of westerly winds in the mid-latitudes. However the transport mechanisms and pollutants transported are not always the same. The transport usually occurs in the free troposphere, above the atmospheric boundary layer. Vertical motions can then bring these pollutants down to the surface. These transport events are highly episodic and last from 1-3 days. Pollutants that we have detected to date in these transport events include carbon monoxide, ozone, hydrocarbons, sulfate and mercury. While generally the levels we observe are only moderate, on occasion, we do see concentrations that approach, or even exceed, new air quality standards. These pollutants reflect sources in Asia, including: industrial sources, photochemical smog, biomass burning, and/or mineral dust. In a few cases, involving large amounts of mineral dust or smoke, these pollutants have been detected by satellites, but generally, the pollutant “streams” are not visible on available satellite observations. We have also worked with global models to track and identify individual episodes of pollution transport. These models have improved substantially in recent years and are frequently able to reproduce individual transport events. In addition, we have some evidence that long-range transport can impact wet deposition on the west coast, but to date, the evidence is sparse.

We now need to turn our attention to the question of what is the impact of this transport on air quality and deposition in the western U.S. In this paper I will present an overview of the long-range transport issue, discuss some recent data on the impacts and present a framework for examining the environmental significance of this phenomenon.

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Evidence of Transport of Mongolian Dust to the Continental United States using CASTNet (Clean Air Status and Trends Network) Data

*Christopher M. Rogers, Thomas F. Lavery, and H. Kemp Howell
Harding ESE, Inc.[1]

During April 2001, an anomalously intense dust storm erupted in the Gobi Desert of Mongolia lifting dust and other particles out of the boundary layer and into upper levels of the troposphere. Once there, the dust was transported across the northern Pacific, eventually contacting the continental United States. The transport of the particles was measured using the NASA Total Ozone Mapping Spectrometer (TOMS) Aerosol Index product developed by the Ozone Processing Team at the Goddard Space Flight Center and was qualitatively verified using other satellite imagery products. Elevated levels of crustal elements were found through analysis of Teflon filters included in standard CASTNet filter packs operated during the month of April. In particular, time series of calcium, potassium, and magnesium concentrations indicate peak levels which can be associated temporally with the arrival and transport of the dust particles across the continental United States. Maps of weekly atmospheric concentrations for the three cations also indicate transport and break-up of the dust cloud.

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POSTER SESSION
(IN ALPHABETICAL ORDER BY CORRESPONDING AUTHOR)

Twenty Five Years of Analytical Evolution

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The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) has been a highly recognized program for atmospheric chemistry research for nearly 25 years–providing a nationwide data base of precipitation chemistry to scientists and policy makers. It has evolved from a small network of twenty two sites in 1978 to the much expanded program today encompassing over 245 sites in 2002 (of which 20 plus sites are still the originals). This program began as, and still is, a cooperative effort between local, private, state and federal organizations, a few of which include the United State Geological Survey, the United States Forest Service, the United States Environmental Protection Agency, the National Park Service, National Oceanic and Atmospheric Administration (NOAA), the State Agricultural Experiment Stations and many others. This network provides a long term set of data on atmospheric chemical deposition to the nation's agricultural crops, streams and lakes, forests and other natural and man-made resources. Complementing the growth of the program have been two more networks, the Atmospheric Integrated Research Monitoring Network(AIRMoN-10 sites), added in 1992, and the Mercury Deposition Network (MDN-60+ sites), added in 1996.

This growth of the NADP/NTN has occurred for many reasons, one being the continuous participation and consistent quality of data provided by the Central Analytical Laboratory (CAL). The analytical laboratory has grown from its inception with only three staff chemists to well over 20 full and part-time personnel. As the number of sites grew so did the needs of the laboratory. Laboratory space and instrumentation also increased. Technology also advanced–what was "top of the line" in instrumentation and precise methodology in 1978 soon grew to be out of date. The CAL constantly strives to advance its sample processing and analytical testing to respond to the demands of the research community by improving detection levels, sample throughput, and data quality.

A historical review of the laboratory's analytical progress from 1978 testing measurement techniques to the present will be presented**. Approaching twenty five years of progress and still improving and moving forward.**

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Next Generation Precipitation Sampler

*William H. Bauman III[1] and Mark C. Beaubien
Yankee Environmental Systems, Inc.[2]

A new and updated design of a precipitation sampler is presented. Many components of this sampler have been redesigned or improved to better facilitate more efficient operations in the National Atmospheric Deposition Program (NADP) and Mercury Deposition Network (MDN). Great care has been taken to minimize precipitation splash by designing a sampler without a large flat surface near the sampler collector, locating the lid farther from the collector, positioning the motor under the collector, and having the lid at a steep angle facing away from the collector. Also, the collector itself is larger to prevent precipitation loss during windy snowfall events. An improved switch/sensor is installed to quickly activate the lid motor under all precipitation conditions to ensure collection during the start of the event. Data can be directly integrated with the existing NADP data ingest and the software supports future intelligent precipitation gauges. A capability to utilize Infrared Data Association (IrDA) communications is included. With a Palm™ handheld device a user can capture data directly through the wireless IrDA port on the sampler.

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Atmospheric Deposition Collection Systems for General Purpose and Trace Metals Studies

John S. Beach, Jr., Vice President
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As no analyses can be more accurate than the samples on which they are made, the importance of representative and reliable sample collection is essential. The evolution over the past two decades of analytical requirements and techniques have created the need for a new generation of precipitation samplers. One of the most essential is for collection of uncontaminated samples for mercury and methyl mercury analyses.

Design consideration include:

- Reliability, in uncovering and covering of the sample collection container(s) at the onset and end of a precipitation event
- Performance monitoring by “on-board” data loggers
- Minimize splash and sample contamination
- Ability to perform in a wide range of temperatures and wind conditions
- Simple to install, yet rugged
- Ease of field maintenance

This paper describes the development of two new atmospheric deposition samplers to meet the stringent criteria of NADP/NTN, MDN and other precipitation chemistry networks, based on technical requirements and user “wish lists”.

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Evaluation of Three Modern Electronic Recording Precipitation Gages

*Roger D. Claybrooke, Scotty R. Dossett, and Van C. Bowersox
Illinois State Water Survey[1]

Consider this: "*The Fergusson gage marked a turning point in the measurement of precipitation and is one of the United States most important contributions to the field. The principal innovation with the gage is that .....the rain or snow fall directly into the receiver where its weight is recorded. The receiver or pail rests on a platform that is supported by a calibrated spring. The downward motion of the pail, as it becomes filled, is transmitted to a recording chart on a clock-operated drum. "* (Kurtyka, John C. U.S. Army Signal Corp Engineering Laboratory Annual Report, 1953, Contract DA-36-039, Fort Monmouth, New Jersey, 178 pages)

This writer describes the introduction of a state-of-the-science gage almost identical to the one NADP uses today. The date;1889.

This poster reviews the field installation, operation, and data from tests of three modern electronic recording precipitation gages. Two of the gages (the OTT PLUVIO and the ETI NOAH III) employ load cell technology and one (the GEONOR T200) uses vibrating wire technology. These gages are compared with the NADP standard BELFORT B5-780 (a Fergusson type gage) using a standard NWS 8" "stick" gage as a reference. The poster addresses reliability, performance, and operational limitations and problems. The gages are ranked according to their suitability for NADP use.

The OTT PLUVIO showed itself superior during statistical analysis of the data after false positives were removed. Compared to the NWS gage, there were no statistically significant differences found. There were 132 events collected from the OTT and the average amount collected was 0.29", which was identical to the NWS gage for those same events. The gage recorded several false positive amounts totaling 1.07" out of a total of 38.13" (or 2.8%). These appear to be temperature related.

The ETI NOAH III gage recorded the most false positive counts of the three gages, due to a temperature compensation problem. During 18 events the total amount of these false positives was over 2.00". There have only been seven events analyzed from the ETI NOAH III gage due to the false positive problem. For these the average amount collected was only 0.02" greater than that of the NWS gage. This gage does have the unique feature of having redundant sensors, one load cell and one optical.

The GEONOR T200 gage had the fewest false positive amounts totaling only 0.02". However, it collected an average amount of 0.32" in 60 events, which was 0.02" less than the NWS stick gage.

The BELFORT B5-780 collected a total amount and an average amount of approximately 12% less than the NWS gage in all of the studies comparing the different raingages, .

Both the ETI and GEONOR gages use a Campbell Scientific CR10X Datalogger to store and filter the data. The data are easily retrievable in the field by conventional PDA or laptop. The retrieved data is comma delimited which can be imported easily into most database and spreadsheet software packages. An additional benefit of the Campbell Datalogger is the ability to store large amounts of data and programs in a relatively small storage module, which dramatically increases the ease of use. The OTT PLUVIO is by far the most cumbersome to use among the three gages tested. Due to the proprietary nature of its electronics and software, a laptop PC or OTT VOTA transmission device must be used to download the data from the gage. The data must then be converted to a database or spreadsheet format for analysis.

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A Closer Look at National Atmospheric Deposition Split Samples

*Brigita Demir and Jane Rothert
Illinois State Water Survey[1]

Two percent of National Atmospheric Deposition (NTN) samples are split for duplicate analyses and given unique identification numbers. Duplicates are separated by at least 200 samples from their original samples. The replicates are blind to the analysts. Replicate sample values are used to calculate the precision of real precipitation samples.

Currently, the standard deviation estimated from paired measurements is calculated at three levels, e.g. from the detection limits to the median values, from the median values to the highest values, and for all values. The Median Absolute Difference (MAD) is also used to calculate dispersion.

In this poster, we will more closely examine the replicate pairs for chloride, nitrate, and sulfate. This examination will, hopefully, lead to new ways of looking at existing replicate data and to expand the role of replicate data as a quality assurance tool.

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Monthly and Annual Bias in Weekly (NADP/NTN) versus Daily (AIRMoN) Precipitation Chemistry Data in the Eastern U.S.A.

*Alice B. Gilliland[1]
U. S. Environmental Protection Agency
Thomas J. Butler[2]
Institute of Ecosystem Studies
Gene E. Likens[3]
Cornell University

Previous comparisons of the data from the National Atmospheric Deposition Program (NADP) National Trends Network (NTN) against collocated event- and daily-sampled data suggest a substantial bias in the concentration of ammonium [NH_4^+] and concentrations of several base cations, while the comparability of other ion concentrations ranges among the studies. Eight years of collocated data from five NTN and Atmospheric Integrated Research and Monitoring Network (AIRMoN) sites are compared here. Unlike previous analyses, the data from these two datasets were analyzed in the same laboratory using the same analytical methods; therefore, factors that influence concentration differences can be isolated to sampling frequency and sample preservation techniques. For comparison, the relative biases for these data have been calculated using both median value and volume-weighted mean concentrations, following two different approaches in the literature. The results suggest a relative bias of about 10% in [NH_4^+] (NTN less than AIRMoN), which is smaller than previous estimates that included the influence of inter-laboratory comparisons. The NTN and AIRMoN data are also compared on monthly and annual time scales to consider whether there are strong seasonal or interannual differences between the networks. The annual relative bias of [H^+] increases over the analysis period, which also results in a larger total relative bias for [H^+] than found in a previous analysis of AIRMoN and NTN data. When comparing NTN and AIRMoN data on monthly time scales, strong seasonal variations are evident in the relative bias for [H^+], [NH_4^+], and [$SO_4^=$]. Large biases in [$SO_4^=$] (NTN greater than AIRMoN) on monthly times scales have not been detected in previous analyses where data for all seasons were considered together.

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Total and Organic Nitrogen in NADP Precipitation Samples–A Preliminary Study

*Karen S. Harlin[1], Susan R. Bachman, and Ryan Wuebbles
Illinois State Water Survey[2]

Nitrogen measurements in National Atmospheric Deposition Program (NADP) precipitation samples have focused on the inorganic nitrogen ions nitrate and ammonium. Current research indicates that a significant percentage of atmospheric nitrogen deposition (up to 30% or more) may be dissolved organic nitrogen (DON) in some samples. The NADP Central Analytical Laboratory (CAL) developed a Total Nitrogen (TN) in-line persulfate digestion method to measure total nitrogen levels in precipitation samples. Organic nitrogen is calculated from the formula DON = TN - (NO_3-N + NH_4-N). A preliminary study is currently in progress to validate the method and to measure TN in NADP samples as they arrive at the CAL. The method detection limit was determined to be 0.01 mg/L TN. Recovery of EDTA-N at 1.0 and 0.1 mg/L was 97.6% and 102.4% respectively. Recovery of urea-N at 1.0 and 0.1 mg/L was 100.8% and 102.7% respectively. NADP has two networks which measure major ions in precipitation. The National Trends Network (NTN) collects weekly precipitation samples from 244 sites throughout the U.S., Puerto Rico, and the Virgin Islands. The Atmospheric Integrated Research Monitoring Network (AIRMoN) collects samples within 24 hours of precipitation events from 10 sites in the eastern U.S. NTN samples are maintained at ambient temperatures and AIRMoN samples are refrigerated immediately after collection. Data will be presented on TN and DON levels in samples from both networks and the effects of filtration on TN levels.

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A Classification Scheme for NADP Sites

Robert S. Larson[1]
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A site classification scheme is described that estimates the potential influence of local anthropogenic sources on the atmospheric deposition at National Atmospheric Deposition Program (NADP) sites. The primary classification characterizes each site as being urban, rural, suburban, or isolated. The population density within 15 km of each site determines the site's classification. Changes in population density over time can be tracked by using data from the U.S. Census Bureau's decennial census for 1980, 1990, and 2000.

The classification scheme is extended using additional supplemental regarding SO_2 emissions, NOx emissions, and road density. The 1999 emissions inventory developed by the U.S. Environmental Protection Agency are used to estimate the emissions within 50 km of each NADP site. The Census Bureau's 2000 TIGER/Line database are used to estimate the road density within 5 km of NADP sites.

To facilitate comparison between sites, each of the metrics is converted to a percentile value. The site-specific values are compared to the distribution of values that occur within the continental United States. The distributions for each metric are determined using Geographic Information Systems (GIS) techniques.

An alphabetic character that indicates if a site is within 50 km of an ocean further characterizes each site.

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Evaluation of NADP Minimum Reporting Levels by Analysis of Method Detection Levels and Split Sample Data

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The NADP is evaluating minimum reporting levels (MRL) for chemical concentrations to define and standardize the relationship between MRLs and with laboratory method detection levels (MDLs). CAL MDLs are computed annually to establish control limits, but MDLs may vary day-to-day, depending on laboratory conditions. Laboratory MDLs can be averaged over time to determine long-term method detection levels (LT-MDL), which are relatively stable.

In January 2000, CAL began using a low level spiked solution as an internal blind quality control sample, and uses these results to calculate LT-MDLs. It is proposed to set MRLs at twice the LT-MDL, which will statistically balance the chance of false positives and false negatives (Type I vs. Type II statistical error). For data before 2000, sample variability can be determined by analyzing low-concentration split sample data. This sample split data may provide a surrogate means of estimating the LT-MDL. Such data is available from the beginning of NADP. In this presentation, a comparison will be made between the variability of LT-MDL data and sample split data for 2000 and 2001. This study will determine if sample split data is a valid means of estimating the LT-MDL for samples prior to January 2000.

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Summary of Field Site Systems and Performance Survey Results for 1998-2001

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Illinois State Water Survey[2]

NADP Field Site Systems and Performance Surveys fulfill several quality assurance purposes: Field equipment is verified and calibrated; field operators are evaluated and retrained to ensure they are following correct procedures; and site conditions are documented and characterized to ensure compliance with siting criteria. Advanced Technology Systems of Pittsburgh, PA visited 400 NTN and 38 MDN sites from 1998 through 2001. This presentation will provide a summary of field survey findings for this period.

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Investigation of Differences Between Field and Laboratory pH Measurements of NADP/NTN Precipitation Samples

*Natalie Latysh and John Gordon[1]
U. S. Geological Survey

This study was undertaken to investigate differences between laboratory and field pH measurements for precipitation samples collected from 135 weekly precipitation-monitoring sites in the National Trends Network from 12/30/1986 to 12/28/1999. Differences in pH between field and laboratory measurements occurred for 96% of samples collected during this time period. Differences between the two measurements were evaluated for precipitation samples collected before and after January 1994, when modifications to sample-shipping procedures and elimination of the contaminating bucket o-ring used in sample shipment occurred. Median hydrogen-ion differences between field and laboratory measurements declined from 3.9 µeq/L before the 1994 protocol change to 1.4 µeq/L after the 1994 protocol change. Hydrogen-ion differences between field and laboratory measurements had a high correlation with the sample pH determined in the field. The largest pH differences between the two measurements occurred for high-pH samples (> 5.6), typical of precipitation collected in Western United States; however low-pH samples (< 5.0) displayed the highest variability in hydrogen-ion differences between field and laboratory analyses. Properly screened field pH measurements are a useful alternative to laboratory pH values for trend analysis, particularly before 1994 when laboratory pH values were influenced by sample-collection equipment.

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The Importance of Dry Deposition in Coastal Regions – Hoh Rain Forest Olympic National Park

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University of Washington[2]

Since 1985 we have been collecting bulk precipitation at various sites near the Hoh Rain Forest in Olympic National Park. Comparing data from bulk collectors and the NADP wet-only collector at the Hoh Ranger Station (WA14) shows that dry deposition is a significant proportion of input to the region, and that it may be a particularly important source of atmospheric NO3, SO4 and Ca. Moreover, episodes of enhanced deposition, such as that observed during the winters of 1994, 1995 and 1996, appear to consist almost entirely of dry deposition. It appears that wet-only deposition is not an accurate metric of total deposition to coastal regions of the Pacific Northwest, and neglecting dry deposition may lead to inaccurate conclusions about the magnitude of inputs to the region, potentially impairing the ability of forest and aquatic ecologists to evaluate the impact of pollution on systems that they study.

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Use of National Atmospheric Deposition Program Data to Develop Deposition Analysis Thresholds for Class I Area AQRV Protection

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Tamara Blett[2]
National Park Service

As Federal Land Managers, the U.S. Fish and Wildlife Service (FWS) and the National Park Service (NPS) are responsible for protecting air quality and air quality related values (AQRVs) in Class I areas under their jurisdiction. AQRVs are resources that may be adversely affected by a change in air quality. Certain AQRVs, including lakes, streams, soils, and estuaries, are sensitive to atmospheric deposition of nitrogen (N) and sulfur (S). Effects include acidification, fertilization or eutrophication and subsequent biological and ecological changes. In the past, there has been no consistent method used by FWS and NPS to evaluate how high incremental deposition increases on Class I areas would have to be before the ability to protect these AQRVs might be affected.

The FWS and NPS have developed Deposition Analysis Thresholds (DATs) for evaluating increases in N and S deposition to Class I areas. A DAT is the additional amount of N or S deposition within a Class I area, below which estimated impacts from a proposed new or modified air pollution source are considered insignificant. DATs are based on estimates of annual natural background deposition from the eastern and western U.S. These estimates are then scaled from annual deposition to smaller amounts relevant to single source deposition contributions. Data from the National Atmospheric Deposition Program (NADP), as well as other available deposition data and modeling information, were used to develop DATs. A DAT is a deposition threshold, not necessarily an adverse impact threshold. When a DAT is predicted to be exceeded, the FWS and NPS will consider, on a case-by-case basis, the magnitude of the deposition as well as the sensitivity of the ecosystem. FWS and NPS anticipate that DATs will improve the permit review process by providing a quantitative method with which to evaluate N and S deposition in Class I areas.

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Measuring Total Nitrogen in Precipitation: A Report on the Maryland Pilot Study

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Mark Castro[2]
University of Maryland Center for Environmental Science

Atmospheric deposition has been identified as a major source of the nutrient nitrogen that contributes to hypoxia episodes observed in coastal and estuarine waters of the United States. Data from the National Atmospheric Deposition Program [NADP] have formed the basis for estimating the contribution from atmospheric deposition to the nutrient nitrogen load in these waters. The nitrogen species in the NADP analyte list are ammonium and nitrate. It is suspected that there may be other, probably organic, forms of nitrogen that may be part of the total N-deposition. The data reported here are from the current pilot study by the Maryland Department of Natural Resources and the University of Maryland Center for Environmental Science, Appalachian Laboratory, to compare the sum of ammonium and nitrate levels in selected NADP samples to that obtained by a total nitrogen analysis. This presentation is a continuation of the work presented at the Fall 2001 NADP meeting in which the analytical method and QA/QC issues were discussed.

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Trends in the Concentration and Wet Deposition of Mercury: MDN 1995-2001

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Illinois State Water Survey
Robert Brunette[2] and Eric Prestbo[2]
Frontier Geosciences, Inc.

Between 1995 and 2001, NADP's Mercury Deposition Network (MDN) grew from 14 sites to over 50 sites across the U.S. and Canada. The median total mercury concentration for almost 7000 samples collected in MDN during this period is 10 ng/L. Volume-weighted total mercury concentrations in precipitation are lowest at remote sites in northern California and the Canadian maritime provinces (4 to 5 ng/L) and highest in Florida and Minnesota (14 to15 ng/L). Wet deposition of mercury ranges from over 25 µg/m^2/yr in south Florida to less than 3 µg/m2/yr at remote western sites. Mercury deposition is strongly seasonal in eastern North America. In summer, the average mercury concentration is about double and the average wet deposition is about three times that found in winter. Over the period MDN has been in operation, there is no significant time trend in rainfall amount, mercury concentration, or wet deposition except in the Minnesota-Wisconsin region. In this region, mercury concentration and deposition, but not rainfall amount, increased by 5 to 10% per year.

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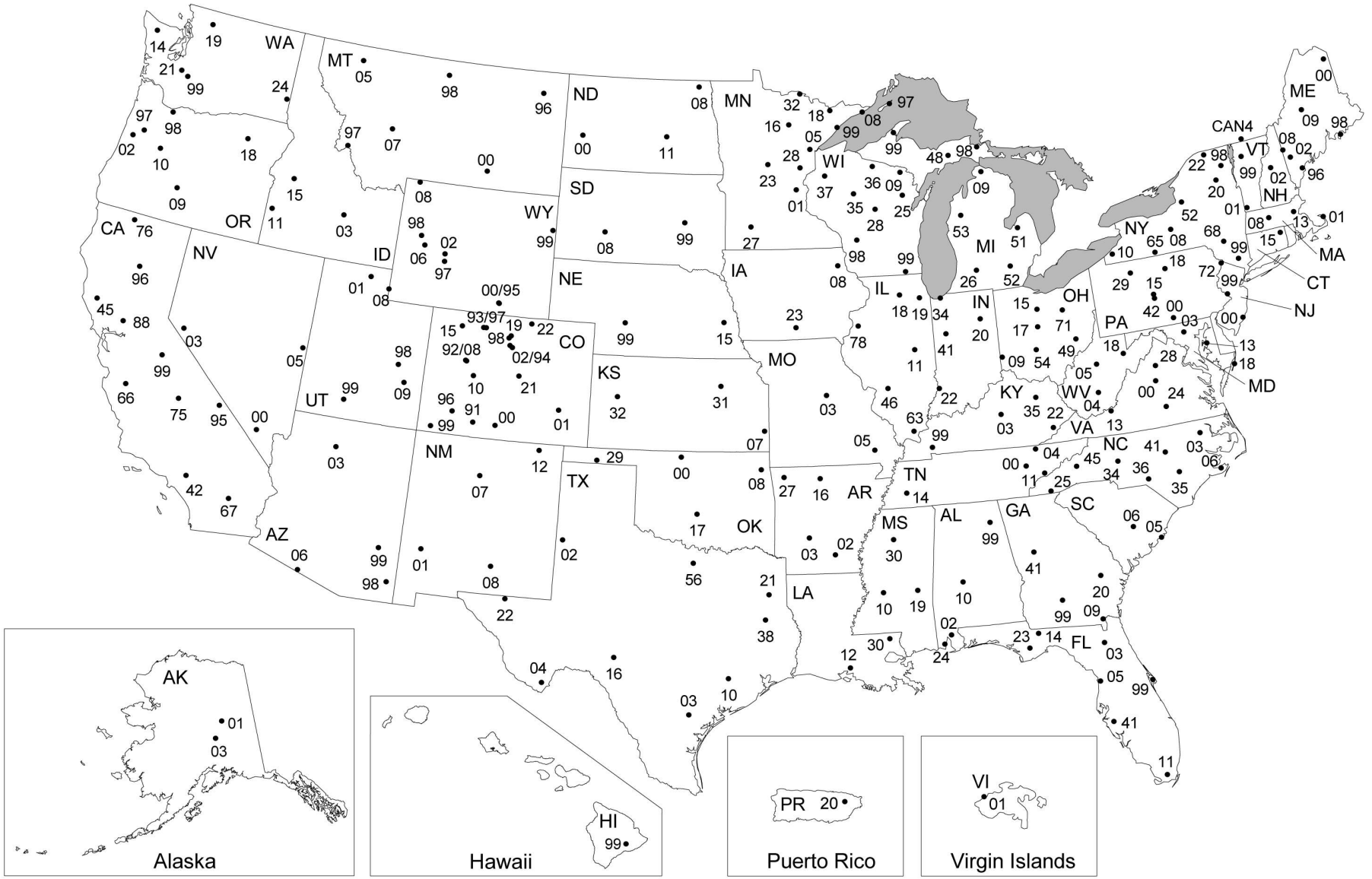
Phase III-Evaluation of the Ott-Pluvio Rain Gage versus the Belfort 5-780 Rain Gage for Modernizing the National Atmospheric Deposition Program

Mary L. Tumbusch
U.S. Geological Survey

The National Atmospheric Deposition Program (NADP) operates a rainfall collection network at 240 sites. The rainfall is currently measured by the Belfort 5-780 rain gage, using over 50-year old technology. In 1999, a three-phase study was undertaken to find a possible replacement for the Belfort gage. One gage that performed consistently well in Phase I and II was the Ott-Pluvio (OP) rain gage. Phase III of the rain-gage evaluation was to determine the accuracy and compatibility of the rainfall collected by the OP gages with the existing Belfort gages and the NovaLynx National Weather Service (NWS) stick gage as a reference at two sites. The OP gages were deployed at six NADP sites across the country for 18 months of data collection. Paired t-test results indicated no significant difference between gages at three of the six sites. When false positives where removed from the data set all sites indicated no differences between gages. For the two sites with the NWS stick gages, the paired t-tests indicate the OP and stick gages are not significantly different but the Belfort and stick gages are significantly different.

NTN MAP AND SITE LISTINGS

National Atmospheric Deposition Program
National Trends Network



National Atmospheric Deposition Program/National Trends Network Sites
August 31, 2002

State Site Code	Site Name	County	Sponsoring Agency	Start Date
Alabama				
AL02	Delta Elementary	Baldwin	EPA/Alabama Dept of Environmental Mgt	06/01
AL24	Bay Road	Mobile	EPA/Alabama Dept of Environmental Mgt	05/01
AL10	Black Belt Ag Substation	Dallas	US Geological Survey	08/83
AL99	Sand Mountain Ag Experiment Station	DeKalb	Tennessee Valley Authority	10/84
Alaska				
AK01	Caribou - Poker Creek	Fairbanks	USDA Forest Service	12/92
AK03	Denali NP - Mount McKinley	Denali	National Park Service - Air Resources Div	06/80
Arizona				
AZ03	Grand Canyon NP - Hopi Point	Coconino	National Park Service - Air Resources Div	08/81
AZ06	Organ Pipe Cactus NM	Pima	National Park Service - Air Resources Div	04/80
AZ98	Chiricahua	Cochise	US Environmental Protection Agency-CAMD	02/99
AZ99	Oliver Knoll	Graham	US Geological Survey	08/81
Arkansas				
AR02	Warren 2WSW	Bradley	US Geological Survey	05/82
AR03	Caddo Valley	Clark	US Geological Survey	12/83
AR16	Buffalo NR - Buffalo Point	Marion	National Park Service - Air Resources Div	07/82
AR27	Fayetteville	Washington	US Geological Survey	04/80
California				
CA42	Tanbark Flat	Los Angeles	USDA Forest Service	01/82
CA45	Hopland	Mendocino	US Geological Survey	10/79
CA50	Sagehen Creek	Nevada	US Geological Survey	11/01
CA66	Pinnacles NM - Bear Valley	San Benito	National Park Service - Air Resources Div	11/99
CA67	Joshua Tree NP - Black Rock	San	National Park Service - Air Resources Div	09/00
CA75	Sequoia NP - Giant Forest	Bernardino	National Park Service - Air Resources Div	07/80
CA76	Montague	Tular	US Geological Survey	06/85
CA88	Davis	Siskiyou	US Geological Survey	09/78
CA95	Death Valley NP - Cow Creek	Yolo	National Park Service - Air Resources Div	02/00
CA96	Lassen Volcanic NP - Manzanita Lake	Inyo	National Park Service - Air Resources Div	06/00
CA99	Yosemite NP - Hodgdon Meadow	Shasta Tuolumne	National Park Service - Air Resources Div	12/81
Colorado				
CO00	Alamosa - Weather Service Office	Alamosa	US Geological Survey	04/80
CO01	Las Animas Fish Hatchery	Bent	US Geological Survey	10/83
CO02	Niwot Saddle	Boulder	NSF/INSTAAR-University of Colorado	06/84
CO08	Four Mile Park	Garfield	US Environmental Protection Agency-CAMD	12/87
CO10	Gothic	Gunnison	US Environmental Protection Agency-CAMD	02/99
CO15	Sand Spring	Moffat	Bureau of Land Management	03/79
CO19	Rocky Mountain NP - Beaver Meadows	Larimer	National Park Service - Air Resources Div	05/80
CO21	Manitou	Teller	USDA Forest Service	10/78
CO22	Pawnee	Weld	NSF-LTER/Colorado State University	05/79
CO91	Wolf Creek Pass	Mineral	USDA Forest Service	05/92
CO92	Sunlight Peak	Garfield	US Environmental Protection Agency-CAMD	01/88
CO93	Buffalo Pass - Dry Lake	Routt	USDA Forest Service	10/86
CO94	Sugarloaf	Boulder	US Environmental Protection Agency-CAMD	11/86
CO96	Molas Pass	San Juan	USDA Forest Service	07/86
CO97	Buffalo Pass - Summit Lake	Routt	USDA Forest Service	02/84
CO98	Rocky Mountain NP - Loch Vale	Larimer	USGS/Colorado State University	08/83
CO99	Mesa Verde NP - Chapin Mesa	Montezuma	US Geological Survey	04/81
Connecticut				
CT15	Abington	Windham	US Environmental Protection Agency-CAMD	01/99
Florida				
FL03	Bradford Forest	Bradford	St. John's River Water Management District	10/78
FL05	Chassahowitzka NWR	Citrus	US Fish & Wildlife Serv - Air Quality Branch	08/96
FL11	Everglades NP - Research Center	Dade	National Park Service - Air Resources Div	06/80
FL14	Quincy	Gadsden	US Geological Survey	03/84
FL23	Sumatra	Liberty	US Environmental Protection Agency-CAMD	01/99
FL41	Verna Well Field	Sarasota	US Geological Survey	08/83
FL99	Kennedy Space Center	Brevard	NASA/Dynamac Corporation	08/83

State Site Code	Site Name	County	Sponsoring Agency	Start Date
Georgia				
GA09	Okefenokee NWR	Charlton	US Fish & Wildlife Serv - Air Quality Branch	06/97
GA20	Bellville	Bellville	US Environmental Protection Agency-CAMD	04/83
GA41	Georgia Station	Pike	SAES-University of Georgia	10/78
GA98	Skidaway	Chatham	US Environmental Protection Agency-CAMD	06/02
GA99	Chula	Tift	US Geological Survey	02/94
Hawaii				
HI99	Hawaii Volcanoes NP - Thurston	Hawaii	National Park Service - Air Resources Div	11/00
Idaho				
ID03	Craters of the Moon NM	Butte	National Park Service - Air Resources Div	08/80
ID11	Reynolds Creek	Owyhee	US Geological Survey	11/83
ID15	Smiths Ferry	Valley	US Geological Survey	10/84
Illinois				
IL11	Bondville	Champaign	SAES-University of Illinois	02/79
IL18	Shabbona	DeKalb	SAES-University of Illinois	05/81
IL19	Argonne	DuPage	DOE-Argonne National Laboratory	03/80
IL46	Alhambra	Madison	US Environmental Protection Agency-CAMD	01/99
IL63	Dixon Springs Ag Center	Pope	SAES-University of Illinois	01/79
IL78	Monmouth	Warren	US Geological Survey	01/85
Indiana				
IN20	Huntington Reservoir	Huntington	US Geological Survey	08/83
IN22	Southwest Purdue Ag Center	Knox	US Geological Survey	09/84
IN34	Indiana Dunes NL	Porter	National Park Service - Air Resources Div	07/80
IN41	Purdue University Ag Farm	Tippecanoe	SAES-Purdue University	07/82
Iowa				
IA08	Big Springs Fish Hatchery	Clayton	US Geological Survey	08/84
IA23	McNay Memorial Research Center	Lucas	US Geological Survey	09/84
Kansas				
KS07	Farlington Fish Hatchery	Crawford	US Geological Survey	03/84
KS31	Konza Prairie	Riley	SAES-Kansas State University	08/82
KS32	Lake Scott State Park	Scott	US Geological Survey	03/84
Kentucky				
KY03	Mackville	Washington	US Geological Survey	11/83
KY22	Lilley Cornett Woods	Letcher	NOAA-Air Resources Lab	09/83
KY35	Clark State Fish Hatchery	Rowan	US Geological Survey	08/83
KY99	Mulberry Flats	Trigg	TVA/Murray State University	12/94
Louisiana				
LA12	Iberia Research Station	Iberia	US Geological Survey	11/82
LA30	Southeast Research Station	Washington	US Geological Survey	01/83
Maine				
ME00	Caribou	Aroostook	NOAA-Air Resources Lab	04/80
ME02	Bridgton	Cumberland	Maine Dept of Environmental Protection	09/80
ME04	Carrabassett Valley	Franklin	US Environmental Protection Agency-CAMD	03/02
ME08	Gilead	Oxford	US Geological Survey	09/99
ME09	Greenville Station	Piscataquis	SAES-University of Maine	11/79
ME95	Wolapomomqot Ciw Wocuk	Penobscot	EPA/Passamaquoddy Tribe	06/02
ME96	Casco Bay - Wolfe's Neck Farm	Cumberland	EPA/Maine Dept of Environmental Protection	01/98
ME98	Acadia NP - McFarland Hill	Hancock	National Park Service - Air Resources Div	11/81
Maryland				
MD03	White Rock Substation	Carroll	Constellation Energy Group	10/84
MD13	Wye	Queen Anne	SAES-University of Maryland	03/83
MD18	Assateague Island NS - Woodcock	Worchester	Maryland Department of Natural Resources	09/00
Massachusetts				
MA01	North Atlantic Coastal Lab	Barnstable	National Park Service - Air Resources Div	12/81
MA08	Quabbin Reservoir	Franklin	NESCAUM	03/82
MA13	East	Middlesex	NESCAUM	02/82

State Site Code	Site Name	County	Sponsoring Agency	Start Date
Michigan				
MI09	Douglas Lake- Univ Michigan Biological Station	Cheboygan	USDA/Michigan State University	07/79
MI26	Kellogg Biological Station	Kalamazoo	USDA/Michigan State University	06/79
MI29	Peshawbestown	Leelanau	US Environmental Protection Agency-CAMD	01/02
MI48	Seney NWR - Headquarters	Schoolcraft	US Fish & Wildlife Serv - Air Quality Branch	11/00
MI51	Unionville	Tuscola	US Environmental Protection Agency-CAMD	01/99
MI52	Ann Arbor	Washtenaw	US Environmental Protection Agency-CAMD	01/99
MI53	Wellston	Wexford	USDA Forest Service	10/78
MI97	Isle Royale NP - Wallace Lake	Keneenaw	National Park Service - Air Resources Div	05/85
MI98	Raco	Chippewa	US Environmental Protection Agency-CAMD	05/84
MI99	Chassell	Houghton	National Park Service - Air Resources Div	02/83
Minnesota				
MN01	Cedar Creek	Anoka	Minnesota Pollution Control Agncy	12/96
MN05	Fond du Lac	Carlton	EPA/Fond du Lac Reservation	11/96
MN08	Hovland	Cook	Minnesota Pollution Control Agency	12/96
MN16	Marcell Experimental Forest	Itasca	USDA Forest Service	07/78
MN18	Fernberg	Lake	US Environmental Protection Agency-CAMD	11/80
MN23	Camp Ripley	Morrison	US Geological Survey	10/83
MN27	Lamberton	Redwood	Minnesota Pollution Control Agency	01/79
MN28	Grindstone Lake	Pine	Minnesota Pollution Control Agency	12/96
MN32	Voyageurs NP - Sullivan Bay	St. Louis	National Park Service - Air Resources Div	05/00
MN99	Wolf Ridge	Lake	Minnesota Pollution Control Agency	12/96
Mississippi				
MS10	Clinton	Hinds	US Geological Survey	07/84
MS19	Newton	Newton	NOAA-Air Resources Lab	11/86
MS30	Coffeeville	Yalobusha	Tennessee Valley Authority	07/84
Missouri				
MO03	Ashland Wildlife Area	Boone	US Geological Survey	10/81
MO05	University Forest	Butler	US Geological Survey	10/81
MO43	Tyson Research Center	St. Louis	Washington University	08/01
Montana				
MT00	Little Big Horn Battlefield	Big Horn	US Geological Survey	07/84
MT05	Glacier NP - Fire Weather Station	Flathead	National Park Service - Air Resources Div	06/80
MT07	Clancy	Jefferson	US Geological Survey	01/84
MT96	Poplar River	Roosevelt	EPA/Ft. Peck Tribes	12/99
MT97	Lost Trail Pass	Ravalli	USDA Forest Service	09/90
MT98	Havre	Hill	US Geological Survey	07/85
Nebraska				
NE15	Mead	Saunders	SAES-University of Nebraska	07/78
NE99	North Platte Ag Station	Lincoln	US Geological Survey	09/85
Nevada				
NV00	Red Rock Canyon	Clark	Bureau of Land Management	01/85
NV03	Smith Valley	Smith	US Geological Survey	08/85
NV05	Great Basin NP - Lehman Caves	White Pine	National Park Service - Air Resources Div	01/85
New Hampshire				
NH02	Hubbard Brook	Grafton	USDA Forest Service	07/78
New Jersey				
NJ00	Edwin B. Forsythe NWR	Atlantic	US Fish & Wildlife Serv - Air Quality Branch	10/98
NJ99	Washington Crossing	Mercer	US Environmental Protection Agency-CAMD	08/81
New Mexico				
NM01	Gila Cliff Dwellings NM	Catron	EPA/New Mexico Environment Dept.	07/85
NM07	Bandelier NM	Los Alamos	DOE-Los Alamos National Lab	06/82
NM08	Mayhill	Otero	US Geological Survey	01/84
NM12	Capulin Volcano NM	Union	EPA/New Mexico Environment Dept.	11/84
New York				
NY08	Aurora Research Farm	Cayuga	USDA/Cornell University	04/79
NY10	Chautauqua	Chautauqua	US Geological Survey	06/80
NY20	Huntington Wildlife	Essex	EPA/State Univ of New York-Syracuse	10/78
NY22	St. Regis Mohawk - Fort Covington	Franklin	US Environmental Protection Agency-CAMD	08/99
NY52	Bennett Bridge	Oswego	EPA/State Univ of New York-Oswego	06/80
NY65	Jasper	Steuben	US Geological Survey	02/80
NY68	Biscuit Brook	Ulster	US Geological Survey	10/83
NY98	Whiteface Mountain	Essex	US Geological Survey	07/84
NY99	West Point	Orange	US Geological Survey	09/83

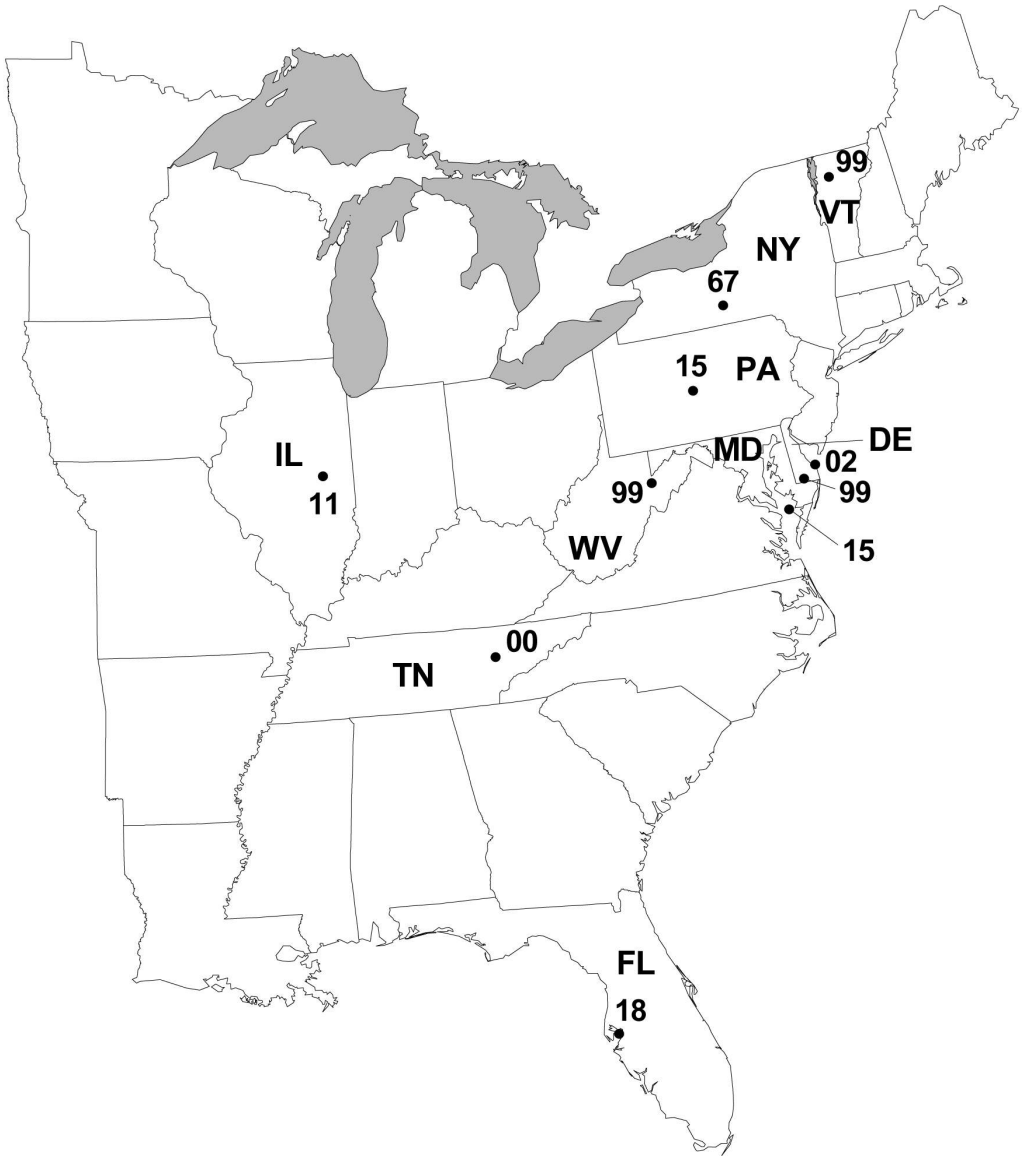
State Site Code	Site Name	County	Sponsoring Agency	Start Date
North Carolina				
NC03	Lewiston	Bertie	North Carolina State University	10/78
NC06	Beaufort	Carteret	US Environmental Protection Agency-CAMD	01/99
NC25	Coweeta	Macon	USDA Forest Service	07/78
NC29	Hofmann Forest	Onslow	North Carolina State University	07/02
NC34	Piedmont Research Station	Rowan	North Carolina State University	10/78
NC35	Clinton Crops Research Station	Sampson	North Carolina State University	10/78
NC36	Jordan Creek	Scotland	US Geological Survey	10/83
NC41	Finley Farms	Wake	North Carolina State University	10/78
NC45	Mount Mitchell	Yancey	North Carolina State University	11/85
North Dakota				
ND00	Theodore Roosevelt NP-Painted Canyon	Billings	National Park Service-Air Resources Div	01/01
ND08	Icelandic State Park	Pembina	US Geological Survey	10/83
ND11	Woodworth	Stutsman	US Geological Survey	11/83
Ohio				
OH09	Oxford	Butler	US Geological Survey	08/84
OH15	Lykens	Crawford	US Environmental Protection Agency-CAMD	01/99
OH17	Delaware	Delaware	USDA Forest Service	10/78
OH49	Caldwell	Noble	US Geological Survey	09/78
OH54	Deer Creek State Park	Pickaway	US Environmental Protection Agency-CAMD	01/99
OH71	Wooster	Wayne	US Geological Survey	09/78
Oklahoma				
OK00	Salt Plains NWR	Alfalfa	US Geological Survey	12/83
OK08	Lake Eucha	Delaware	EPA/Oklahoma Conservation Commission	02/00
OK17	Great Plains Apiaries	McClain	NOAA-Air Resources Lab	03/83
OK29	Goodwell Research Station	Texas	US Geological Survey	01/85
Oregon				
*OR02	Alsea Guard Ranger Station	Benton	US Environmental Protection Agency-CAMD	12/79
OR09	Silver Lake Ranger Station	Lake	US Geological Survey	08/83
OR10	H J Andrews Experimental Forest	Lane	USDA Forest Service	05/80
OR18	Starkey Experimental Forest	Union	US Geological Survey	03/84
OR97	Hyslop Farm	Benton	US Environmental Protection Agency-CAMD	04/83
OR98	Bull Run	Clackamas	USGS/Portland Water Bureau, OR	07/82
Pennsylvania				
PA00	Arendtsville	Adams	US Environmental Protection Agency-CAMD	01/99
PA15	Penn State	Centre	NOAA-Air Resources Lab	06/83
PA18	Young Woman's Creek	Clinton	US Geological Survey	04/99
PA29	Kane Experimental Forest	Elk	USDA Forest Service	07/78
PA42	Leading Ridge	Huntingdon	SAES-Pennsylvania State University	04/79
PA72	Milford	Pike	USDA Forest Service	12/83
Puerto Rico				
PR20	El Verde	Rio Grande	USDA Forest Service	02/85
South Carolina				
SC05	Cape Romain - NWR	Charleston	US Fish & Wildlife Serv - Air Quality Branch	11/00
SC06	Santee NWR	Clarendon	US Geological Survey	07/84
SC07	Ace Basin NERR	Colleton	US Environmental Protection Agency-CAMD	12/01
SC11	North Inlet Winyah Bay Nat Estuarine Res Resv	Georgetown	US Environmental Protection Agency-CAMD	01/02
SC99	Fort Johnson	Charleston	US Environmental Protection Agency-CAMD	03/02
South Dakota				
SD08	Cottonwood	Jackson	NOAA-Air Resources Lab	10/83
SD99	Huron Well Field	Huron	US Geological Survey	11/83
Tennessee				
TN00	Walker Branch Watershed	Anderson	DOE/Oak Ridge Natl Lab/Lockheed-Martin	03/80
TN04	Speedwell	Claiborne	US Environmental Protection Agency-CAMD	01/99
TN11	Great Smoky Mountain NP - Elkmont	Sevier	National Park Service - Air Resources Div	08/80
TN14	Hatchie NWR	Haywood	Tennessee Valley Authority	10/84

State Site Code	Site Name	County	Sponsoring Agency	Start Date
Texas				
TX02	Muleshoe NWR	Bailey	US Geological Survey	06/85
TX03	Beeville	Bee	NOAA-Air Resources Lab	02/84
TX04	Big Bend NP - K-Bar	Brewster	National Park Service - Air Resources Div	04/80
TX10	Attwater Prairie Chicken NWR	Colorado	US Geological Survey	07/84
TX16	Sonora	Edwards	US Geological Survey	06/84
TX21	Longview	Gregg	Texas Natural Resource Conservation Comm	06/82
TX22	Guadalupe Mountains NP-Frijole Ranger Station	Culberson	US Geological Survey	06/84
TX39	Texas A&M Corpus Christi	Nueces	EPA/Texas A&M University	01/02
TX56	LBJ National Grasslands	Wise	US Geological Survey	09/83
Utah				
UT01	Logan	Cache	US Geological Survey	12/83
UT08	Murphy Ridge	Rich	BP Amoco	03/86
UT09	Canyonlands NP - Island in the Sky	San Juan	National Park Service - Air Resources Div	11/97
UT98	Green River	Emery	US Geological Survey	04/85
UT99	Bryce Canyon NP - Repeater Hill	Garfield	National Park Service - Air Resources Div	01/85
Vermont				
VT01	Bennington	Bennington	US Geological Survey	04/81
VT99	Underhill	Chittenden	US Geological Survey	06/84
Virgin Islands				
VI01	Virgin Islands NP - Lind Point	St. John	National Park Service - Air Resources Div	04/98
Virginia				
VA00	Charlottesville	Albemarle	US Geological Survey	10/84
VA13	Horton's Station	Giles	Tennessee Valley Authority	07/78
VA24	Prince Edward	Prince Edward	US Environmental Protection Agency-CAMD	01/99
VA27	James Madison University Farm	Rockinham	US Environmental Protection Agency-CAMD	07/02
VA28	Shenandoah NP - Big Meadows	Madison	National Park Service - Air Resources Div	05/81
VA99	Natural Bridge Station	Rockbridge	Virginia Department of Environmental Quality	07/02
Washington				
WA14	Olympic NP - Hoh Ranger Station	Jefferson	National Park Service - Air Resources Div	05/80
WA19	North Cascades NP-Marblemount Ranger Station	Skagit	US Geological Survey	02/84
WA21	La Grande	Pierce	US Environmental Protection Agency-CAMD	04/84
WA24	Palouse Conservation Farm	Whitman	US Geological Survey	08/85
WA98	Columbia River Gorge	Skamania	USDA Forest Service - Region 6	05/02
WA99	Mount Rainier NP - Tahoma Woods	Pierce	National Park Service - Air Resources Div	10/99
West Virginia				
WV04	Babcock State Park	Fayette	US Geological Survey	09/83
WV05	Cedar Creek State Park	Gilmer	US Environmental Protection Agency-CAMD	01/99
WV18	Parsons	Tucker	USDA Forest Service	07/78
Wisconsin				
WI09	Popple River	Florence	Wisconsin Department of Natural Resources	12/86
WI25	Suring	Oconto	Wisconsin Department of Natural Resources	01/85
WI28	Lake Dubay	Portage	Wisconsin Department of Natural Resources	06/82
WI32	Middle Village	Shawano	EPA/Menominee Indian Tribe	01/02
WI35	Perkinstown	Taylor	US Environmental Protection Agency-CAMD	01/99
WI36	Trout Lake	Vilas	Wisconsin Department of Natural Resources	01/80
WI37	Spooner	Washburn	Wisconsin Department of Natural Resources	06/80
WI97	Lac Courte Oreilles Reservation	Sawyer	EPA/Lac Courte Oreilles Conservation Dept	11/01
*WI98	Wildcat Mountain	Vernon	Wisconsin Department of Natural Resources	08/89
WI99	Lake Geneva	Walworth	Wisconsin Department of Natural Resources	06/84
Wyoming				
WY00	Snowy Range - West Glacier Lake	Albany	USDA Forest Service	04/86
WY02	Sinks Canyon	Fremont	Bureau of Land Management	08/84
WY06	Pinedale	Sublette	Bureau of Land Management	01/82
WY08	Yellowstone NP - Tower	Park	National Park Service - Air Resources Div	06/80
WY95	Brooklyn Lake	Albany	USDA Forest Service	09/92
WY97	South Pass City	Fremont	SF Phosphates Ltd. - Bridger Teton NF	04/85
WY98	Gypsum Creek	Sublette	Exxon Mobil Corporation	12/84
WY99	Newcastle	Weston	Bureau of Land Management	08/81
Canada				
CAN5	Frelighsburg		US Geological Survey	10/01

*At these sites the USGS sponsors a second collector for the purpose of measuring network precision.

AIRMoN Map and Site Listings

National Atmospheric Deposition Program
Atmospheric Integrated Research Monitoring Network



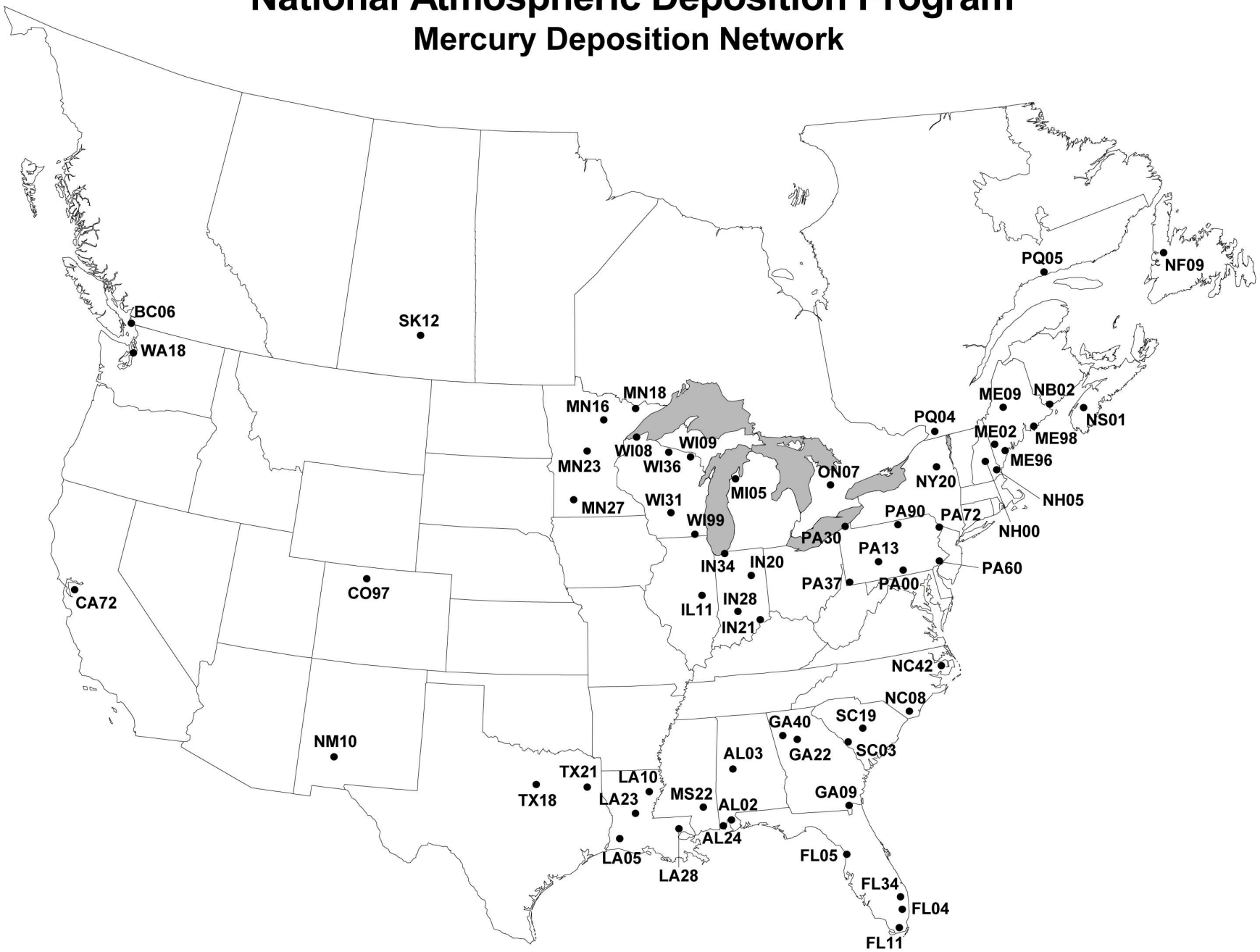
NADP/Atmospheric Integrated Research Monitoring Network Sites
August 31, 2002

State Site Code	Site Name	County	Sponsoring Agency	Start Date
Delaware				
DE02	Lewes	Sussex	NOAA-Air Resources Laboratory	09/92
DE99	Trap Pawn State Park	Sussex	NOAA-Air Resources Laboratory	05/01
Florida				
FL18	Tampa Bay	Hillsborough	FL-Department of Environmental Protection	08/96
Illinois				
IL11	Bondville	Champaign	NOAA-Air Resources Laboratory	10/92
Maryland				
MD15	Smith Island	Somerset	NOAA-Air Resources Laboratory	11/95
New York				
NY67	Cornell University	Thompkins	NOAA-Air Resources Laboratory	09/92
Pennsylvania				
PA15	Penn State	Centre	NOAA-Air Resources Laboratory	10/92
Tennessee				
TN00	Oak Ridge National Lab	Anderson	NOAA-Air Resources Laboratory	09/92
Vermont				
VT99	Underhill	Chittenden	NOAA-Air Resources Laboratory	01/93
West Virginia				
WV99	Canaan Valley Institute	Tucker	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
August 31, 2002

State/Province Site Code	Site Name	County	Sponsoring Agency	Start Date
Alabama				
AL02	Delta Elementary	Baldwin	EPA/Alabama Department of Environmental Management	06/01
AL03	Centreville	Bibb	Southern Company/Atmospheric Research and Analysis, Inc.	06/00
AL24	Bay Road	Mobile	EPA/Alabama Department of Environmental Management	05/01
California				
CA72	San Jose	Santa Clara	EPA/San Francisco Estuary Institute	01/00
Colorado				
CO97	Buffalo Pass - Summit Lake	Routt	USDA Forest Service-Rocky Mountain Research Station	09/98
CO99	Mesa Verde NP-Chapin Mesa	Montezuma	EPA/Office of Wetlands, Oceans, & Watersheds	12/01
Florida				
FL04	Andytown	Broward	S FL Water Mgt Dist/FL Dept of Environmental Protection	01/98
FL05	Chassahowitzka NWR	Citrus	US Fish and Wildlife Service - Air Quality Branch	07/97
FL11	Everglades NP - Research Center	Dade	S FL Water Mgt Dist/FL Dept of Environmental Protection	12/95*
FL34	ENRP	Palm Beach	S FL Water Mgt Dist/FL Dept of Environmental Protection	07/97
Georgia				
GA09	Okefenokee NWR	Charlton	US Fish and Wildlife Service - Air Quality Branch	07/97
GA22	Jefferson Street	Fulton	Southern Company/Atmospheric Research and Analysis, Inc.	06/02
GA40	Yorkville	Paulding	Southern Company/Atmospheric Research and Analysis, Inc.	06/00
Illinois				
**IL11	Bondville	Champaign	Illinois State Water Survey	12/95*
Indiana				
IN20	Huntington Reservoir	Huntington	Indiana Department of Environmental Management/USGS	10/00
IN21	Clifty Falls State Park	Jefferson	Indiana Department of Environmental Management/USGS	01/01
IN28	Bloomington	Monroe	Indiana Department of Environmental Management/USGS	12/00
IN34	Indiana Dunes National Lakeshore	Porter	Indiana Department of Environmental Management/USGS	10/00
Louisiana				
LA05	Lake Charles	Calcasieu	Louisiana Department of Environmental Quality	10/98
LA10	Chase	Franklin	Louisiana Department of Environmental Quality	10/98
LA23	Alexandria	Rapides	Louisiana Department of Environmental Quality	02/01
LA28	Hammond	Tangipahoa	Louisiana Department of Environmental Quality	10/98
Maine				
ME02	Bridgton	Cumberland	Maine Department of Environmental Protection	06/97
ME09	Greenville Station	Piscataquis	Maine Department of Environmental Protection	09/96
ME96	Casco Bay - Wolfe's Neck Farm	Cumberland	Maine Department of Environmental Protection	01/98
ME98	Acadia NP - McFarland Hill	Hancock	NPS-Acadia NP & ME Dept of Environmental Protection	01/96*
Minnesota				
MN16	Marcell Experimental Forest	Itasca	USDA Forest Service-North Central Research Station	12/95*
MN18	Fernberg	Lake	USDA- FS, Superior NF & MN Pollution Control Agency	01/96*
MN22	Mille Lacs Band of Ojibwe	Mille Lacs	EPA/Mille Lacs Band of Ojibwe	04/02
MN23	Camp Ripley	Morrison	Minnesota Pollution Control Agency	07/96
MN27	Lamberton	Redwood	Minnesota Pollution Control Agency	07/96
Mississippi				
MS22	Oak Grove	Perry	Southern Company/Atmospheric Research and Analysis, Inc.	06/00
New Hampshire				
NH00	Laconia	Belknap	New Hampshire Department of Environmental Services	01/98***
NH05	New Castle	Rockingham	New Hampshire Department of Environmental Services	10/97***
New Mexico				
NM10	Caballo	Sierra	Bureau of Reclamation/New Mexico State University	05/97

State/Province Site Code	Site Name	County	Sponsoring Agency	Start Date
North Carolina				
NC08	Waccamaw State Park	Columbus	North Carolina Dept of Environment & Natural Resources	12/95*
NC42	Pettigrew State Park	Washington	North Carolina Dept of Environment & Natural Resources	12/95*
New York				
NY20	Huntington Wildlife	Essex	EPA/State University of New York - Syracuse	12/99
Pennsylvania				
PA00	Arendtsville	Adams	PA Dept of Environmental Protection/Penn State University	11/00
PA13	Allegheny Portage Railroad NHS	Cambria	PA Dept of Environmental Protection/Penn State University	01/97
PA30	Erie	Erie	PA Dept of Environmental Protection/Penn State University	06/00
PA37	Holbrooke	Greene	US Dept of Energy/National Energy Technology Laboratory	05/99
PA60	Valley Forge	Montgomery	PA Dept of Environmental Protection/Penn State University	11/99
PA72	Milford	Pike	PA Dept of Environmental Protection/Penn State University	09/00
PA90	Hills Creek State Park	Tioga	PA Dept of Environmental Protection/Penn State University	01/97
South Carolina				
SC03	Savannah River	Barnwell	US Dept of Energy/Westinghouse Savannah River Co	01/01
SC19	Congaree Swamp State Park	Richland	South Carolina Dept of Health & Environmental Quality	12/95*
Texas				
TX21	Longview	Gregg	Texas Natural Resource Conservation Commission	12/95*
TX50	Fort Worth	Tarrant	EPA/Ft Worth Department of Environmental Management	08/01
Washington				
WA18	Seattle - NOAA	King	Frontier Geosciences, Inc	03/96
Wisconsin				
WI08	Brule River	Douglas	Wisconsin Department of Natural Resources	12/95*
WI09	Popple River	Florence	Wisconsin Department of Natural Resources	12/95
WI31	Devils Lake	Sauk	Wisconsin Department of Natural Resources	01/01
WI32	Middle Village	Shawano	EPA/Menominee Indian Tribe	01/02
WI36	Trout Lake	Vilas	Wisconsin Department of Natural Resources	12/95*
WI99	Lake Geneva	Walworth	Wisconsin Department of Natural Resources	01/97
Wyoming				
WY07	Yellowstone Lake	Teton	US Environmental Protection Agency - Region 8	12/01
CANADA				
British Columbia				
BC06	Reifel Island		Environment Canada - Pacific and Yukon Region	03/00
New Brunswick				
NB02	St. Andrews		Environment Canada - Meteorological Service of Canada	07/96
Newfoundland				
NF09	Newfoundland		Environment Canada - Meteorological Service of Canada	05/00
Nova Scotia				
NS01	Kejimkujik NP		Environment Canada - Meteorological Service of Canada	07/96
Ontario				
ON07	Egbert		Environment Canada - Air Quality Research Branch	03/00
ON10	Burnt Island		Environment Canada - Environmental Conservation Service	12/01
ON11	Point Petre		Environment Canada - Environmental Conservation Service	12/01
Quebec				
PQ04	Saint Anicet		Environment Canada - Meteo Service of Canada-Quebec Region	04/98
PQ05	Mingan		Environment Canada - Meteo Service of Canada-Quebec Region	04/98
Saskatchewan				
SK12	Regina		Environment Canada - Prairie and Northern Region	08/01

*These dates mark the official start of NADP/MDN operations. Data for a transition network operating in 1995 are available from the NADP web site at http://nadp.sws.uiuc.edu.
**At this site the NADP Program Office sponsors a second collector for the purpose of measuring network precision.
***Sampling was discontinued at NH00 and NH05 on 6/30/02.

PROCEEDINGS NOTES

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