NADP 2004
Technical Committee Meeting and Scientific Symposium

September 21-23, 2004
Halifax, Nova Scotia
Canada

Technical Program Chair
Cari Sasser Furiness
College of Natural Resources
North Carolina State University
Raleigh, NC
USA

PROCEEDINGS

Prepared by

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September 2004

The NADP would like to acknowledge the many contributions of our colleagues at Environment Canada over the past year during the planning of this Annual Technical Committee Meeting and Scientific Symposium. Chul-Un Ro, Rob Tordon, and Rhonda Doyle LeBlanc, as well as others, have provided invaluable assistance in choosing and negotiating the venue for the meeting, making arrangements for the field trip, soliciting our keynote speaker and other presentations, and sponsoring the evening harbour cruise and luncheon. We, and especially Technical Program Chair, Cari Furiness, are very grateful for their generous support.

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NADP TECHNICAL COMMITTEE MEETING AGENDA

NADP 2004 Technical Committee Meeting andScientific Symposium Block Agenda
Halifax, Nova Scotia Canada

	21-Sep-2004	22-Sep-2004		
Time	**Tuesday**	**Wednesday**		**Time**
0700	Registration Open	Registration Open		0700
0800	**Joint Subcommittee Meeting**	**Annual Technical Committee Business Meeting**		0800
0820				0820
0840				0840
0900				0900
0920				0920
0940		(break)		0940
1000		**Atmospheric Deposition Databases and Data Products *(Session Chair: Robert Vet, Environment Canada)***	Ro - *The Canadian National Atmospheric Chemistry Precipitation Database and Products*	1000
1020	(break)		Rogers - *The CASTNET Dry Deposition Database*	1020
1040	**Subcommittee Meetings**		McClure - *An Approach to Atmospheric Deposition Data Management and Data Products*	1040
1100			Lear - *Interpreting Results through Maps: Intersection of Facts and Perception*	1100
1120		**Critical Loads and Recovery in Aquatic Ecosystems *(Session Chair: Dean Jeffries, Environment Canada)***	Morrison - *The 2004 Canadian Acid Deposition Assessment*	1120
1140			Clair - *Past and Future Changes to Acidified Eastern Canadian Lakes: A Geochemical Modeling Approach*	1140
1200	**Lunch (on your own)**		**Lunch (on your own)**	1200
1230				1230
1300	**Subcommittee Meetings**			1300
1330			Jeffries - *Aquatic Effects of Acidic Deposition: Ecosystem Critical Loads and Recovery in Canada*	1330
1350			Hartman - *Modeling the Timeline for Lake and Stream Acidification from Excess Nitrogen Deposition for Rocky Mountain National Park*	1350
1410		**Critical Loads and Recovery in Terrestrial Ecosystems *(Session Chair: Pamela Padgett, US Forest Service)***	Driscoll - *Critical Loads and the Response of a Northern Forest Ecosystem to Changes in Atmospheric Deposition*	1410
1430			Huntington - Status of Soil Acidification in North America	1430
1450	(break)		Cox - Spatial Modeling of Marine Fog Water Deposition with Application to Acidifying Substances and Mercury Input to Forests Adjacent to the Bay of Fundy	1450
1510	**Executive Committee Meeting**		(break)	1510
1530			*Arp - Mapping Critical Soil Acidification Loads for Eastern Canada and New England*	1530
1550			Miller - Forest Sensitivity to Nitrogen and Sulfur Deposition in New England	1550
1610		**Atmospheric Deposition Issues (Session Chair: Cari S. Furiness, North Carolina State Univ.)**	Winstanley - *Hypoxia in the Gulf of Mexico: Controlling the Wrong Pollutant?*	1610
1630			Donahue - *Economic Impacts of Acid Rain on Building Corrosion in Eastern Canada*	1630
1650			Malek - *Meteorological Aspects of the Worst National Air Pollution (January 2004) in Logan, Cache County, Utah, USA*	1650
1700				
1710				1710
1730			**Poster Session and Reception/Social Mixer**	1730
1800				1800
1830				1830
1900				1900
1930				1930
2000				2000

NADP 2004 Technical Committee Meeting andScientific Symposium Block Agenda
Halifax, Nova Scotia Canada

	23-Sep-2004		24-Sep-2004	
Time	**Thursday**		**Friday**	**Time**
0700	Registration Open			0700
0800		Lawrence -*Climate Dependency of Tree Growth Suppressed by Acid Deposition in Northwest Russia*	**Field Trip Kejimkujik National Park**	0800
0820	**Dry Deposition Estimates (Session Chair: Gary Lear, US EPA)**	Butler - *The Impact of Changing* NO_x *Emissions on* HNO_3 *Dry Deposition for CASTNET Sites in the Northeastern, Mid-Atlantic, and Midwestern USA*		0820
0840		Padgett - *Vegetation as Passive Collectors…Maybe Not*		0840
0900		Walker - *Air-surface Exchange of Ammonia over Soybean*		0900
0920		Kolian - *Application of High Resolution, Continuous Instruments at CASTNET Sites*		0920
0940		(break)		0940
1000	**Estimates of N and S Deposition *(Session Chair: Viney Aneja, North Carolina State University)***	Vet - *An Overview of Wet, Dry, and Total Deposition of Sulphur and Nitrogen in Canada*		1000
1020		Finkelstein - *Comparison of Spatial Patterns of Wet Deposition to Model Predictions*		1020
1040		Korfmacher - *Long-term Wet- and Dry-deposition Trends at the Glacier Lakes Ecosystem Experiment Site (GLEES)*		1040
1100		Lehmann - *Trends in Sulfur and Nitrogen Species at Collocated NADP-NTN and CASTNET Sites*		1100
1120		Aneja - *Agricultural Ammonia Emissions and Ammonium Concentrations Associated with Precipitation in the Southeast United States*		1120
1140	**Deposition of Mercury *(Session Chair: David Gay, National Atmospheric Deposition Program)***	Artz - *Modeling the Atmospheric Transport and Deposition of Mercury in the U.S. and Canada*		1140
1200		**Luncheon Speaker: Barry Stemshorn, Asst. Deputy Minister, Environment Canada** ***Canadian Acid Rain & Air Quality Issues with a View Towards Transboundary Concerns***		1200
1230				1230
1300				1300
1330		Hansen - *Monitoring Pilot Project for Wet Deposition of Mercury in Mexico*		1330
1350		Blanchard - *Recent Results from the Canadian Atmospheric Mercury Measurement Network (CAMNet)*		1350
1410		Miller - *Estimation and Mapping of Mercury Deposition to Northeastern North America*		1410
1430		Peckenham - *Geochemical Associations of Background Mercury Concentrations in Maine Rivers*		1430
1450		Mason - *Wet and Dry Deposition of Mercury in Maryland*		1450
1510		(break)		1510
1530	**Deposition of Mercury and Other Trace Metals *(Session Chair: Steve Beauchamp, Environment Canada)***	Risch - *Measurement of Atmospheric Mercury Species with Manual-collection and Analysis Methods to Estimate Mercury Dry-deposition Rates in Indiana*		1530
1550		Mast - *Mercury Deposition in the Loch Vale Watershed in Rocky Mountain National Park, Colorado, 2002-2003*		1550
1610		Gürleyük - *Determination of Arsenic, Selenium, and Various Trace Metals in Rain Waters*		1610
1630		Lamborg - $Hg/^{210}Pb$ *Correlations in Precipitation and their Use in Apportioning Regional and Global Components of Current and Historical Hg Deposition*		1630
1650		Rice - *Atmospheric Wet Deposition of Trace Elements to a Suburban Environment near Washington, D.C., USA*		1650
1700				
1710				1710
1730				1730
1800				1800
1830				1830
1900				1900
1930				1930
2000				2000

NADP Tecnical Committee Meeting
Halifax, Nova Scotia
CANADA
September 21-23, 2004

TUESDAY, September 21, 2004		**Room Location**
	Registration Desk Open All Day	
8:00 a.m. to 10:20 a.m.	Joint Committee Meeting NOS, DMAS, & Effects	Cavalier Room
10:20 a.m. to 10:40 a.m.	Break	
10:40 a.m. to 12:00 p.m.	Subcommittee Meetings	
	NOS	Cavalier Room
	DMAS	Terrace Room East
	Effects	Terrace Room West
12:00 p.m. to 1:00 p.m.	Lunch (on your own)	
1:00 p.m. to 2:50 p.m.	Subcommittee Meetings	
2:50 p.m. to 3:10 p.m.	Break	
3:10 p.m. to 5:00 p.m.	Executive Committee Meeting	Cavalier Room

WEDNESDAY, September 22, 2004		**Room Location**
7:00 a.m.	Registration	
8:00 a.m. to 9:40 a.m.	Annual Technical Committee Business Meeting	Cavalier Room
9:40 a.m. to 10:00 a.m.	Break	
TECHNICAL SESSION:	**ATMOSPHERIC DEPOSITION DATABASES AND DATA PRODUCTS** Session Chair: Robert Vet, Environment Canada	Cavalier Room
10:00 - 10:20	***The Canadian National Atmospheric Chemistry Precipitation Database and Products*** Chul-Un Ro, Environment Canada	
10:20 - 10:40	***The CASTNET Dry Deposition Database*** Christopher M. Rogers, MACTEC	
10:40 - 11:00	***An Approach to Atmospheric Deposition Data Management and Data Products*** Shawn McClure, Colorado State University	
11:00 - 11:20	***Interpreting Results through Maps: Intersection of Facts and Perception*** Gary G. Lear, U.S. Environmental Protection Agency	

WEDNESDAY, September 22 2004		**Room Location**
TECHNICAL SESSION:	**CRITICAL LOADS AND RECOVERY IN AQUATIC ECOSYSTEMS** Session Chair: Dean Jeffries, Environment Canada	Cavalier Room
11:20 - 11:40	***The 2004 Canadian Acid Deposition Assessment*** Dr. Heather Morrison, Environment Canada	
11:40 - 12:00	***Past and Future Changes to Acidified Eastern Canadian Lakes: A Geochemical Modeling Approach*** Tom Clair, Environment Canada	
12:00 p.m. to 1:30 p.m.	Lunch (on your own)	
1:30 - 1:50	***Aquatic Effects of Acidic Deposition: Ecosystem Critical Loads and Recovery in Canada*** D.S. Jeffries, Environment Canada	
1:50 - 2:10	***Modeling the Timeline for Lake and Stream Acidification from Excess Nitrogen Deposition for Rocky Mountain National Park*** M.D. Hartman, Colorado State University	
TECHNICAL SESSION:	**CRITICAL LOADS AND RECOVERY IN TERRESTRIAL ECOSYSTEMS** Session Chair: Pamela Padgett, U.S. Forest Service	Cavalier Room
2:10-2:30	***Critical Loads and the Response of a Northern Forest Ecosystem to Changes in Atmospheric Deposition*** Charles T. Driscoll, Syracuse University	
2:30-2:50	***Status of Soil Acidification in North America*** T.G. Huntington, U.S. Geological Survey	
2:50-3:10	***Spatial Modeling of Marine Fog Water Deposition with Application to Acidifying Substances and Mercury Input to Forests Adjacent to the Bay of Fundy*** R. M. Cox, Natural Resources Canada	
3:10 p.m. to 3:30 p.m.	Break	
3:30-3:50	***Mapping Critical Soil Acidification Loads for Eastern Canada and New England*** Paul A. Arp, University of New Brunswick	
3:50-4:10	***Forest Sensitivity to Nitrogen and Sulfur Deposition in New England*** Eric K. Miller, Ecosystems Research Group, Ltd.	

WEDNESDAY, September 22 2004		**Room Location**
TECHNICAL SESSION:	**ATMOSPHERIC DEPOSITION ISSUES** Session Chair: Cari S. Furiness, North Carolina State University	Cavalier Room
4:10-4:30	***Hypoxia in the Gulf of Mexico: Controlling the Wrong Pollutant?*** Derek Winstanley, Illinois State Water Survey	
4:30-4:50	***Economic Impacts of Acid Rain on Building Corrosion in Eastern Canada*** Michael Donohue, Environment Canada	
4:50-5:10	***Meteorological Aspects of the Worst National Air Pollution (January 2004) In Logan, Cache County, Utah, U.S.A.*** Esmaiel Malek, Utah State University	
5:30 p.m. to 8:00 p.m.	**POSTER SESSION - SOCIAL MIXER**	Terrace Rooms

THURSDAY, September 23, 2004		**Room Location**
7:00 a.m.	Registration	
TECHNICAL SESSION:	**ATMOSPHERIC DEPOSITION ISSUES (CONTINUED)** Session Chair: Cari S. Furiness, North Carolina State University	Cavalier Room
8:00 - 8:20	***Climate Dependency of Tree Growth Suppressed by Acid Deposition in Northwest Russia*** G. B. Lawrence, U.S. Geological Survey	
TECHNICAL SESSION:	**DRY DEPOSITION ESTIMATES** Session Chair: Gary Lear, U.S. Environmental Protection Agency	
8:20 - 8:40	***The Impact of Changing NO$_x$ Emissions on HNO$_3$ Dry Deposition for CASTNET Sites in the Northeastern, Mid-Atlantic, and Midwestern USA*** Thomas J. Butler, Cornell University	
8:40 - 9:00	***Vegetation as Passive Collectors…Maybe Not*** Pamela Padgett, U.S. Forest Service	
9:00 - 9:20	***Air-Surface Exchange of Ammonia over Soybean*** John Walker, U.S. Environmental Protection Agency	
9:20 - 9:40	***Application of High Resolution, Continuous Instruments at CASTNET Sites*** Michael Kolian, U.S. Environmental Protection Agency	
9:40 p.m. to 10:00 a.m.	Break	

THURSDAY, September 23, 2004 **Room Location**

TECHNICAL SESSION: **ESTIMATES OF N AND S DEPOSITION** Cavalier Room
Session Chair: Viney Aneja, North Carolina State University

10:00 - 10:20 ***An Overview of Wet, Dry, and Total Deposition of Sulphur and Nitrogen in Canada***
Robert Vet, Environment Canada

10:20 - 10:40 ***Comparison of Spatial Patterns of Wet Deposition to Model Predictions***
Peter L. Finkelstein, National Oceanic and Atmospheric Administration

10:40-11:00 ***Long-term Wet- and Dry-deposition Trends at the Glacier Lakes Ecosystem Experiments Site (GLEES)***
John L. Korfmacher, USDA Forest Service

11:00 - 11:20 ***Trends in Sulfur and Nitrogen Species at Collocated NADP-NTN and CASTNET Sites***
Christopher Lehmann, National Atmospheric Deposition Program

11:20 - 11:40 ***Agricultural Ammonia Emissions and Ammonium Concentrations Associated with Precipitation in the Southeast United States***
Viney P. Aneja, North Carolina State University

TECHNICAL SESSION: **DEPOSITION OF MERCURY**
Session Chair: David Gay, National Atmospheric Deposition Program

11:40 - 12:00 ***Modeling the Atmospheric Transport and Deposition of Mercury in the U.S. and Canada***
Richard Artz, National Oceanic and Atmospheric Administration

12:00 p.m. - 1:30 p.m. **Luncheon - Invited Speaker**
Dr. Barry Stemshorn, Assistant Deputy Minister
Environment Canada

TECHNICAL SESSION: **DEPOSITION OF MERCURY (CONTINUED)** Cavalier Room
Session Chair: David Gay, National Atmospheric Deposition Program

1:30 - 1:50 ***Monitoring Pilot Project for Wet Deposition of Mercury in Mexico***
Anne M. Hansen, Instituto Mexicano de Tecnología del Agua (IMTA)

1:50 - 2:10 ***Recent Results from the Canadian Atmospheric Mercury Measurement Network (CAMNet)***
Pierrette Blanchard, Environment Canada

THURSDAY, September 23, 2004		**Room Location**
TECHNICAL SESSION:	**DEPOSITION OF MERCURY (CONTINUED)** Session Chair: David Gay, National Atmospheric Deposition Program	Cavalier Room
2:10 - 2:30	***Estimation and Mapping of Mercury Deposition to Northeastern North America*** Eric K. Miller, Ecosystems Research Group, Ltd.	
2:30 - 2:50	***Geochemical Associations of Background Mercury Concentrations in Maine Rivers*** John M. Peckenham, University of Maine	
2:50 - 3:10	***Wet and Dry Deposition of Mercury in Maryland*** R.P. Mason, Chesapeake Biological Laboratory (CBL)	
3:10 p.m. to 3:30 p.m.	Break	
TECHNICAL SESSION:	**DEPOSITION OF MERCURY AND OTHER TRACE METALS** Session Chair: Steve Beauchamp, Environment Canada	Cavalier Room
3:30 - 3:50	***Measurement of Atmospheric Mercury Species with Manual-collection and Analysis Methods to Estimate Mercury Dry-deposition Rates in Indiana*** Martin R. Risch, U.S. Geological Survey	
3:50 - 4:10	***Mercury Deposition in the Loch Vale Watershed in Rocky Mountain National Park, Colorado, 2002-2003*** M. Alisa Mast, U.S. Geological Survey	
4:10 - 4:30	***Determination of Arsenic, Selenium, and Various Trace Metals in Rain Waters*** Hakan Gürleyük, Frontier Geosciences	
4:30 - 4:50	***Hg/^{210}Pb Correlations in Precipitation and their Use in Apportioning Regional and Global Components of Current and Historical Hg Deposition*** Carl H. Lamborg, Woods Hole Oceanographic Institution	
4:50 - 5:10	***Atmospheric Wet Deposition of Trace Elements to a Suburban Environment near Washington, D.C. USA*** Karen C. Rice, U.S. Geological Survey	

Field Trip
Kejimkujik National Park

September 24, 2004
Board bus at 9:00 a.m.
Box lunch provided

Established in 1967, Kejimkujik National Park's vast interior landscape covers 381 square kilometers of lush forest, slow moving streams and island-studded lakes, providing a taste of Nova Scotia's imposing inland wilderness. The high level of rainfall is essential to streams, which flood regularly in the spring, and the numerous shallow lakes that sustain both wildlife and flora. The Seaside Adjunct of Kejimkujik National Park, the rock-girded coastal section, where birds, reptiles and amphibians are particularly abundant, occupies 22 square kilometres at the tip of the Port Mouton peninsula.

Micmac people lived here for more than 4,000 years, whose history can still be sighted with hundreds of petroglyphs (carvings) depicting legends and events. Scottish and Irish immigrants settled in the area in the 1760s. The park's name comes from a Micmac word referring to the exertion required in paddling across the lake.

Kejimkujik National Park is a canoeist's paradise, as it features the best canoeing in eastern Canada. You can canoe or kayak on the many waterways travelled by the Micmac, surrounded only by nature and tranquility. There are 15 walking trails for all hiking levels, with a length of 0.5 to 6 km.

2004 NADP SITE OPERATOR AWARDS

	NTN Site/Site Name	Operator Name	Wet Start	Agency
5 Year Awards				
CO99	Mesa Verde National Park - Chapin Mesa	Sylvia Oliva	4/28/81	USGS
GA99	Chula	Charles Welsh	2/10/94	USGS
MA01	North Atlantic Coastal Lab	Evan Gwilliam	12/15/81	NPS-ARD
MN05	Fond du Lac	Joy Wiecks	11/19/96	EPA/Fond du Lac Reservation
MN99	Wolf Ridge	Kurt Mead	12/31/96	Minnesota PCA
NC06	Beaufort	Nathan Hall	1/26/99	EPA
NC35	Clinton Crops Research Station	Steve Honrine	10/24/78	NCSU
NH02	Hubbard Brook	Ralph Perron	7/25/78	USFS
OR02/OR97	Alsea Guard Ranger Station/ Hyslop Farm	Lynn Conley	12/27/79 4/26/83	EPA/ EPA
PA00	Arendtsville	Sharon Scamack	1/26/99	EPA
VA24	Prince Edward	Gene Brooks	1/26/99	EPA
WI35	Perkinstown	Clara Emstrom	1/26/99	EPA
10 Year Awards				
AR03	Caddo Valley	Harrell Beckwith	12/30/83	USGS
CA42	Tanbark Flat	Mike Oxford	1/12/82	USFS
NC45	Mt. Mitchell	Gene Berry	1/26/85	NCSU
NV03	Smith Valley	Laurie Bonner	8/7/85	USGS
PR20	El Verde	John Bithorn	2/12/85	USFS
VA28	Shendandoah National Park - Big Meadows	Shane Spitzer	5/12/81	NPS-ARD
15 Year Awards				
AL10	Black Belt Agricultural Experiment Substation	Peggy Seekers	8/31/83	USGS
CO08/CO92	Four Mile Park/ Sunlight Peak	Wayne Ives	12/29/87 1/13/88	EPA/ EPA
IN41	Agronomy Center for Research and Extension	Kenneth Scheeringa	7/13/82	SAES-Purdue Univ
OR18	Starkey Experimental Forest	Cheryl Borum	3/6/84	USGS
TX02	Muleshoe National Wildlife Refuge	Glenda Copley	6/18/85	USGS
20 Year Awards				
CO02/CO94	Niwot Saddle/ Sugarloaf	Mark Losleben	6/5/84 11/4/86	NSF/INSTAAR-UC EPA
MN18	Fernberg	Christine Barton	11/18/80	EPA
MN23	Camp Ripley	Mary McGuire	10/18/83	USGS
MS10	Clinton	Eddie Morris	7/10/84	USGS
ND08	Icelandic State Park	Karen Duray	10/25/83	USGS
WI99	Lake Geneva	Ted Peters	6/5/84	Wisconsin DNR
WY02	Sinks Canyon	Greg Bautz	8/21/84	BLM

TECHNICAL SESSION: ATMOSPHERIC DEPOSITION DATABASES AND DATA PRODUCTS

Session Chair: Robert Vet, Environment Canada

The Canadian National Atmospheric Chemistry Precipitation Database and Products

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The Canadian National Atmospheric Chemistry (NAtChem) Precipitation Database is a data archival and analysis facility operated by the Meteorological Service of Canada (MSC) since 1987. The purpose of the NAtChem database is to enhance atmospheric research through the archival and analysis of North American precipitation chemistry data. Such research includes investigations into the chemical nature of the atmosphere, atmospheric processes, spatial and temporal patterns, source-receptor relationships and long range transport of air pollutants.

The database contains precipitation chemistry/wet deposition data from many major regional-scale networks in North America, which operate/operated at least two years with wide area coverage and regionally-representative sites (rural and background). The database includes data collected from 12 Canadian federal and provincial monitoring networks (467 sites) and 11 major U.S. networks (367 sites) since 1980. The NAtChem analysis facility combines the data from these diverse networks to generate statistical summaries, isopleths maps, time series analyses and other statistical analyses. The NAtChem data products include: quality-assured data in a standard format; annual, seasonal, quarterly, and monthly statistical summary tables; annual and seasonal concentration and deposition maps; and charts showing trends in wet deposition and average concentrations. Most of these products can be downloaded from the NAtChem website (www.msc.ec.gc.ca/natchem) and special data analyses and products also can be requested through this website.

The results of long-term wet deposition analyses show that: (1) there are significant changes in non-sea-salt sulphate (nss$SO_4^{=}$) wet deposition patterns between two 5-year periods (1990-1994 and 1996-2000) due to SO_2 emission reductions in the five years before and after the implementation of the 1995 Phase 1 emission reductions mandated by the United States Clean Air Act Amendments. On the other hand, there appears to be no marked changes in the wet deposition patterns of nitrate (NO_3^-) between the same periods; (2) eastern Canada received approximately 30% of sulphate and nitrate wet deposition in eastern North America while emitting less than 10% of total eastern North American emissions of SO_2 and NO_x; (3) there is a high correlation (r=0.93) between the annual values of total SO_2 emissions in eastern North America and annual total wet deposition fluxes of nss$SO_4^{=}$, but a poor correlation (r=0.49) between integrated NO_x and NO_3^-.

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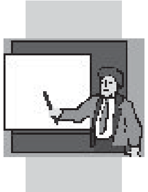

The CASTNET Dry Deposition Database

Christopher M. Rogers*[1], Jon J. Bowser[1], H. Kemp Howell[1], and Kristi H. Morris[2]

In existence since 1991, EPA's Clean Air Status and Trends Network (CASTNET) provides a nationwide, long-term monitoring platform designed to estimate dry deposition. It was created to answer the mandate of the Clean Air Act Amendments passed by Congress in 1990 and incorporated the approximately 50 sites that made up EPA's National Dry Deposition Network (NDDN), which began operation in 1987. Since 1991, many sites have been added to the network, frequently through partnerships with other organizations such as the National Park Service (NPS). Currently, there are 86 CASTNET sites across the United States, 30 of which are sponsored by NPS.

The CASTNET database includes dry deposition data for a seventeen-year period, 1987 through 2003. The values are produced using the Multi-layer Model (MLM), which estimates deposition velocity based on meteorological and site vegetation profile inputs. The product of deposition velocities and atmospheric concentrations is then calculated on an hourly basis. The data set contains weekly, seasonal, quarterly, and annual aggregations in addition to the hourly records. It can be obtained from the EPA CASTNET data access web page: www.epa.gov/castnet/data.html.

Because of the coverage offered by CASTNET, many interesting spatial analyses are possible. For example, spatial deposition patterns along the West Coast of the United States were recently examined. CASTNET also includes numerous sites in sensitive ecosystems. Two such groups of sites are coastal/estuarine sites and sites in the southern Appalachian Mountains of the eastern United States. The southern Appalachian sites include two sites in Great Smoky Mountains National Park: a standard CASTNET site and a specialized site designed to measure the significant contribution of cloud water impaction to total deposition at high elevations.

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An Approach to Atmospheric Deposition Data Management and Data Products

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The Visibility Information Exchange Web System (VIEWS) is an online repository of visibility data, research products, and ideas designed to support the Regional Haze Rule enacted by the U.S. Environmental Protection Agency (EPA) to reduce regional haze in national parks and wilderness areas. In addition to this primary goal, VIEWS supports global efforts to better understand the effects of air pollution on visibility and to improve air quality in general. With the recent addition of data from the NADP/AIRMoN and NADP/NTN networks, interesting comparisons between wet deposition data and aerosol data are now more easily done using the tools and data products on the VIEWS website. By aggregating deposition and aerosol data to common time intervals for similar species, comparisons of short and long terms trends, visualization of spatial distribution with isopleth maps, and analyses of data from collocated sites are now available for a wide variety of monitoring networks. In addition, new insights into the import, transformation, and management of air quality data in general have been gained by the addition of NADP data to the VIEWS database system. By addressing data management challenges and developing tools for integrating data from often dissimilar networks, VIEWS aims to provide researchers, regulators, and the public with a more accurate and available perspective on relevant and comparable air quality data.

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Interpreting Results through Maps: Intersection of Facts and Perception

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One of the most effective methods of communicating monitoring results to a non-scientific audience is through the spatial depiction of data in maps. Accurate representation of results is dependent on using both mathematical algorithms that are appropriate for the data and graphical elements that help the audience discern patterns in an unbiased manner. During its 25-year history, NADP has evolved in the presentation of its data from tedious and laborious hand-drawn isopleth maps to rapid automated methods. Although the presentation has evolved, the spatial interpolation of data has remained essentially the same by using an inverse distance-weighted (IDW) algorithm. While some monitoring networks have adopted interpolation methods similar to NADP (e.g. CASTNET) others such as NAtCHem and SLAMS/NAMS use kriging as their interpolation method of choice. Kriging is an alternative method that provides more accurate spatial estimates for some, but not all, of the analytes reported by NADP and may improve on the spatial interpretation of data. Other visual clues such as topography and land cover may also facilitate the perception of spatial patterns of deposition and rainfall chemistry.

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TECHNICAL SESSION: CRITICAL LOADS AND RECOVERY IN AQUATIC ECOSYSTEMS

Session Chair: Dean Jeffries, Environment Canada

The 2004 Canadian Acid Deposition Assessment

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The 2004 Acid Deposition Science Assessment is a compilation of scientific research and monitoring on acid deposition and its effects in Canada conducted by experts from federal and provincial governments and academia. The purpose of this document is to synthesize the state of knowledge of acid deposition in the context of key policy questions.

The Assessment will address all aspects of acid deposition science including changes in precursor emissions; atmospheric responses and transboundary issues; predicted deposition levels; effects on aquatic and terrestrial ecosystems and expected recovery, critical loads concepts; human health and socio-economic impacts; and the inter-linkages with other air quality issues. An overview of the significant findings, with a focus on critical loads and recovery of eastern Canadian ecosystems, will be presented.

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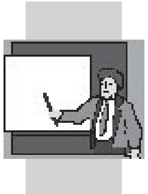

Past and Future Changes to Acidified Eastern Canadian Lakes: A Geochemical Modeling Approach

Tom Clair*[1], Julian Aherne[2], Ian Dennis[1], Mallory Gilliss[3], Suzanne Couture[4], Don McNicol[5], Russ Weeber[5], Peter Dillon[2], Bill Keller[6], Dean Jeffries[7], Stephen Page[8] Jack Cosby[9]

Predictions of past and future water chemistry from 410 lakes spread across a 3000 km east-west gradient in eastern Canada were made using the Model of Acidification of Groundwater in Catchments (MAGIC). The lakes represented a large deposition gradient, as well as a large range of geological sensitivities. After model calibration to current conditions, we applied deposition histories relevant to each region to back calculate pre-acidification pH, acid neutralization capacity (ANC), and dissolved calcium concentrations. We then predicted future water chemistry conditions under both Canadian Federal-Provincial reduction agreements and the predicted United States Clear Skies Agreement. As expected, our results show a wide range of changes from pre-acidification conditions, depending on deposition history and geology. Under the deposition reduction scenario, dissolved calcium will be lower at 60% of the sites in the year 2030, compared to pre-acidification conditions. In addition, neither ANC and pH will return to pre-acidification levels by this time at any of the sites. In our presentation, we discuss these results in the context of critical loads for eastern Canada.

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Aquatic Effects of Acidic Deposition: Ecosystem Critical Loads and Recovery in Canada

D.S. Jeffries*[1], D.C.L. Lam[1], D.K. McNicol[2], R.C. Weeber[2] and I. Wong[1]

Canada's current federal-provincial policy on acid rain abatement (The Canada-Wide Acid Rain Strategy for Post-2000) requires a scientific assessment in 2004. This paper will present an overview of some of the results from the "aquatic effects" chapters, specifically current chemical and biological status of Canadian lakes, trends and evidence of ecosystem recovery, and critical loads and exceedances. In the past, acidification effects have been considered as limited to southeastern Canada (i.e., east of Manitoba and south of 52° N latitude). However, increasing levels of acidifying emissions in western Canada now suggest that aquatic effects may develop where the terrain is sensitive. Lake acidification is still widespread in southeastern Canada. Sulphate deposition remains the predominant acidifying agent, but nitrogen-based acidification may develop in the future, particularly in certain ecosystem types, e,g, hardwood forest catchments. While SO_2 abatement in both Canada and the U.S. has resulted in declining SO_4^{2-} deposition for several years now (particularly in southern Ontario and Quebec), many lakes in southeastern Canada are not showing or are only recently showing declining SO_4^{2-} concentrations. Of those lakes that do exhibit declining SO_4^{2-}, only some show improving acidity status (increasing pH or alkalinity). The principal reason is declining base cations, but other factors also play a role. The best evidence of ecosystem recovery is found near Sudbury, Ontario – a region that has experienced dramatic declines in SO_4^{2-} deposition since the early 1970s due to emission reductions at local smelters. In many cases, lake ecosystems appear to be recovering to a chemical and/or biological state that differs from the original. Critical load analyses confirm that many lakes in southeastern Canada (particularly in highly sensitive terrain in the Atlantic provinces) will continue to experience deposition exceedances.

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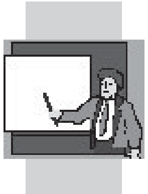

Modeling the Timeline for Lake and Stream Acidification from Excess Nitrogen Deposition for Rocky Mountain National Park

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Nitrogen wet deposition of 3-5 kg N/ha/year to the east side of the Colorado Front Range in Rocky Mountain National Park, in the form of nitrate and ammonium, is among the highest measured in the State. Soils control the potential for lake and stream acidification from excess nitrogen through loss of soil base cations. Base cations leach from soils with acid anions such as sulfate and nitrate. But because nitrogen is a critical plant nutrient, any realistic projection of nitrogen-caused acidification must include an understanding of ecosystem nutrient cycling. We coupled two widely accepted and tested models, one of ecosystem biogeochemistry (the daily version of CENTURY) and the other of soil and water chemical equilibrium (PHREEQC). The model was calibrated for Andrews Creek Watershed, a 160-ha alpine catchment within Loch Vale Watershed covered 88% by bedrock and talus and 11% by tundra and wet meadow soils. The objectives were to model how and when acidification will occur under current and potential future nitrogen deposition amounts. We created nitrogen deposition scenarios by increasing current annual nitrogen deposition rates by 1.25%, 2.5%, and 5.0% per year for 45 years, beginning with current deposition rates the first year. With increasing N-deposition, the model predicts decreasing stream pH and acid neutralizing capacity (ANC), and increasing base cation and nitrate concentrations. With increasing N-deposition, the model shows little increase in total soil organic matter or plant productivity, indicating that Andrews Creek Watershed may have limited capacity to biologically assimilate excess nitrogen. Stream ANC begins to go negative when total wet plus dry N-deposition reaches about 5.0 kg N ha^{-1}year^{-1}. When annual total N-deposition reaches about 7.3 kg N ha^{-1}year^{-1}, ANC goes chronically negative; this begins in year 2016 with the 5.0% scenario, and in year 2031 with the 2.5% scenario.

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TECHNICAL SESSION: CRITICAL LOADS AND RECOVERY IN TERRESTRIAL ECOSYSTEMS

Session Chair: PAMELA PADGETT, U.S. FOREST SERVICE

Critical Loads and the Response of a Northern Forest Ecosystem to Changes in Atmospheric Deposition

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Critical loads have been widely used in Europe to quantify the sensitivity of forest ecosystems to atmospheric deposition and as a management tool to develop emission control programs to protect ecosystems from elevated atmospheric deposition. To determine critical loads, it is necessary to identify values of critical chemical indicators above which biotic resources at risk are not affected by atmospheric deposition. We used the biogeochemical model PnET-BGC to determine critical loads for sulfur and nitrogen at the Hubbard Brook Experimental Forest (HBEF), NH. Current deposition to the biogeochemical reference watershed at the HBEF (w6) exceeds the critical load of sulfur. The critical load of sulfur calculated for the HBEF is much lower than the critical load of nitrate due greater watershed retention of nitrogen than sulfur. There are many difficulties in determining critical loads. The selection of values for critical chemical indicators is problematic. In addition, ecosystem sensitivity to acidic deposition varies over time and therefore the calculated critical load changes over time.

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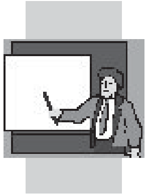

Status of Soil Acidification in North America

T.G. Huntington*, M. E. Fenn[1], S. B. McLaughlin[2], C. Eager[1], A. Gomez[3], and R. B. Cook[2]

Forest soil acidification continues to be an environmental concern in North America and evidence is increasing that both tree harvesting and enhanced soil base cation leaching due to acidic deposition are the primary mechanisms for anthropogenic acidification. One of the more common effects of soil acidification is soil base cation depletion that has been documented by direct re-measurement in New York, Vermont, New Hampshire, Pennsylvania, West Virginia, Tennessee, North Carolina, South Carolina, Ontario, and Quebec. Calcium depletion has also been indicated in a number of other locations using inferential methods, such as input/output budgets or isotopic approaches.

Base cation depletion has been implicated in sugar maple decline in Pennsylvania and Quebec and in the sensitivity of red spruce to winter injury in northeastern North America. There is strong evidence for ongoing forest soil acidification (declining pH and calcium depletion or both) in southern pine and pine-hardwood forests of the southeastern US and mixed conifer and chaparral in southern California, but to date there have been no reported adverse effects on forest health in these areas. Soil acidification due to atmospheric acidic deposition in southern California is presumably from nitrogen deposition and enhanced nitrification rates, because sulfate deposition is low in this region. Pine/fir forests south and southwest of Mexico City receive high levels of sulfate and nitrogen deposition but, owing to the moderately high base saturation of these soils, soil pH changes have been relatively small, especially in *Pinus hartwegii* stands that are characterized by highly open canopy cover. Under *Abies religiosa* stands, which have a dense canopy cover and high leaf area, atmospheric deposition is much higher and corresponding decreases in base cation pools in soil, base saturation and pH are also greater than under pine. Similarly, in California, forest soil acidification is positively correlated with the rate of atmospheric acidic deposition.

Base cation depletion is also implicated in the failure of stream water quality to recover from historical acidification in parts of northeastern North America, in spite of large reductions in sulfate deposition and stream water sulfate concentration. Long-term trends in atmospheric deposition and stream water chemistry in North Carolina and Virginia support the hypothesis that soil retention of atmospherically-derived sulfate has decreased in recent years. If decreased sulfate retention leads to increased sulfate leaching, then soil acidification could accelerate.

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Spatial Modeling of Marine Fog Water Deposition with Application to Acidifying Substances and Mercury Input to Forests Adjacent to the Bay Of Fundy

R. M. Cox*[1], X. B. Zhu[1,2], C. D. Ritchie[2], C-P A. Bourque[2] and P. A. Arp[2]

Fog deposition to forest ecosystem on Point Lepreau Peninsula (PLP), and Grand Manan Island (GMI) NB, Canada, were estimated for two different studies. Each used an empirical algorithm that was adapted and embodies the major fog deposition factors (such as liquid water content and wind velocity) and forest-specific parameters (such as canopy surface roughness and leaf area index). These were measured in the field for different land cover types during the summer of 2002. One study involved fog chemistry data from summer sampling campaigns of 1987-89 and 1996-99, i.e. before and after the signing of the Canada-US Air Quality Accord. Here there was a significant difference (p= 0.0034) in concentration of SO_4^{-2} but not NO_3^{-1} and H^+ between the two data periods. Average sulphate concentration was 315 μeq L^{-1} for 1987-89 and 211 μeq L^{-1} for 1996-99. Rates of deposition of acidity, sulfate and nitrate (μeq m^{-2} h^{-1}) were calculated by multiplying the seasonal mean concentrations (μeq L^{-1}) of sulfate, nitrate, and acidity with the fog-water deposition rate (L m^{-2} h^{-1}) of different land cover types. Results showed that mixed forests have the highest rate of fog deposition, followed by coniferous forests, deciduous forests and clear cuts. Because of the apparent difference in concentration of fog water chemistry between the two data periods, total deposition via fog to PLP was 33.82 % less of sulfate, 1.79 % more of nitrate and 23.4 % less of acidity in summers of the second sampling period (1996, 1998, and 1999), as a possible result of emission controls introduced in the early 1990s. In a different study using the same land cover type classifications at Grand Manan Island (GMI) and using some preliminary seasonal mercury concentrations in fog water collected in 2003-2004, estimates for mercury deposition were derived for the different cover types. The aim was to get an initial view of atmospheric inputs of Hg to the coastal forests. Deposition was compared between PLP(Cranberry Head) and GMI. Preliminary results indicate a surprising difference in Hg concentrations in the fog water between the two sites. At cranberry head (PLP) fog contained 1-31ppt Hg, while at Grand Manan concentrations ranged from 43-437ppt. Hg inputs due to fog interception by coastal forests may be substantial, and are an order of magnitude higher on GMI than on PLP.

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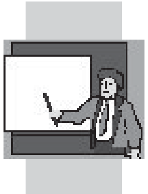

Mapping Critical Soil Acidification Loads for Eastern Canada and New England

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Acid-rain induced base-cation depletion (mainly those of Ca, Mg, K) in forest soils likely interferes with the healthy functioning of forest soils and forest streams. Impacts of sustained atmospheric S and N deposition would be particularly severe in areas where soil-available Ca, Mg, and K supplies are already growth limiting, and where enhanced base-cation losses from soils to streams are occurring. Therefore, it is important to quantify and map rates of base-cation depletion across the potentially impacted forest terrain. This presentation provides an update on the bi-national mapping effort of NEG/ECP Acid Rain Action Plan, as conducted across eastern Canada, including Ontario, and all of the New England States. This includes a summary of process and latest maps centered on the derivation of critical loads of forest soils, and related soil acidification exceedances. Calculated exceedances - in turn - are then examined in the context of forest ecosystem health, as affected by acidification and primary nutrient supplies and losses. It is suggested that further reductions in regional and cross-regional emissions of acid-producing gases will be essential to at least maintain current base-cation levels in soils and streams. The implications of the dynamics of base-cation depletion and potential recovery following emission reduction in forest soils will be emphasized. For example, the recovery of soils from soil acidification is a much slower process than the original rate of soil acidification.

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Forest Sensitivity to Nitrogen and Sulfur Deposition in New England

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Although sulfur emissions have decreased as a result of SO_2 control programs, projected emissions of acidifying sulfur and nitrogen compounds are expected to have continuing negative impacts on forests. These emissions present serious long-term threats to forest health and productivity in northeastern North America. Excess sulfur and nitrogen deposition may reduce the supply of nutrients available for plant growth. Nutrient depletion leads to increases in the susceptibility of forests to climate, pest and pathogen stress which results in reduced forest health, reduced timber yield, and eventual changes in forest species composition.

The Conference of the New England Governors and Eastern Canadian Premiers (NEG/ECP) 1998 Acid Rain Action Plan called for the formation of a Forest Mapping Working Group to conduct a regional assessment of the sensitivity of northeastern North American forests to current and projected sulfur and nitrogen deposition levels. This group is charged with identifying specific forested areas most sensitive to continued sulfur and nitrogen deposition and estimating deposition rates required to maintain forest health and productivity.

The approach we have used to determine acceptable levels of deposition is an ecological assessment based on a steady-state, ecosystem mass balance for nutrient cations (calcium, magnesium, and potassium).Two metrics (*critical load* and *deposition index*) express the result of this assessment. The *critical load* of sulfur + nitrogen is the level of deposition below which no harmful ecological effects occur for a forest ecosystem. The *deposition index* is the difference between the critical load and current deposition and is used to identify sensitive forest ecosystems. Sensitive forest areas were mapped in all jurisdictions completed to date under the current emissions levels of sulfur and nitrogen. For example, in Vermont, current levels of S + N deposition create the conditions for cation depletion in 31% of upland forests (561,127 ha). We estimate that a 50% reduction in S + N deposition would remediate the nutrient depletion problem on 78% of the currently sensitive forest area in Vermont.

Factors that increase forest sensitivity to acid deposition include low mineral weathering rates, and tree species with high nutrient demands. High elevation forests and areas closest to emission sources experience the highest levels of nitrogen and sulfur deposition. Low mineral weathering rates occur in association with particular geologic and climatic factors. Independent ecological indicators have been used to demonstrate that the assessment results are consistent with tree health observations from the region.

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TECHNICAL SESSION: ATMOSPHERIC DEPOSITION ISSUES

Session Chair: Cari S. Furiness, North Carolina State University

Hypoxia in the Gulf of Mexico: Controlling the Wrong Pollutant?

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A 30% reduction of the load of total nitrogen is being implemented in the Mississippi/Atchafalaya River basin in order to reduce the size of the hypoxic zone in the northern Gulf of Mexico. The atmospheric deposition of nitrogen contributes to the load of nitrogen in the Mississippi/Atchafalaya River basin and in coastal areas. Recent analyses indicate that nitrogen is the excess nutrient and that orthophosphate is the limiting nutrient. Reducing the load of nitrogen by 30% is likely to have no significant impact in reducing the size of the hypoxic zone in the Gulf of Mexico. Reducing the load of orthophosphate is likely to be a far more effective strategy to reduce hypoxia. How much biologically available phosphorous is deposited from the atmosphere and what are the sources?

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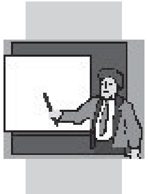

Economic Impacts of Acid Rain on Building Corrosion in Eastern Canada

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The Environmental Economics Branch (EEB) of Environment Canada has been investigating the impacts of acid rain on the corrosion of buildings in Eastern Canada to support ongoing efforts to value the economic benefits of acid rain abatement.

Using dose response functions from Europe and pollution data from NADP and NAPS sites, corrosion rates across Eastern Canada were established for common building materials. Comparing the corrosion rates with identified critical parameters for building repair, the increase in rate of repair due to acid rain was established. The unit building repair costs were used to calculate increased annual repair costs per building and a building inventory was then used to calculate net annual repair costs, by census division, due to acid rain corrosion.

The result of the analysis was that for most buildings in Canada, corrosion due to acid rain does not accelerate the rate at which buildings are repaired or replaced. Comparing the corrosion rates with the identified critical repair parameters, it was discovered that in most cases the critical parameter would not be reached in the standard life time of the buildings.

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Meteorological Aspects of the Worst National Air Pollution (January 2004) in Logan, Cache County Utah, U.S.A.

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Everybody heard the news in January 2004, about the worst national air pollution in Logan, Cache County, Utah, a metropolitan area with a population of about 100,000. Among comments were: “Logan air is the dirtiest in the U.S.,” and “Logan air found worst to breathe in the U.S.” What caused the high concentration of polluted material in the air in Logan during the period 8 - 15 January 2004? From a meteorological point of view, inversion (increase of temperature with height) was the major cause for trapping pollutants in the air. Other meteorological factors enhancing the inversion were: the high atmospheric surface pressure which held down the cold polluted air in the Cache Valley under a thick sheet of warm air; a snow-covered surface which boosted the cold air temperature averaging between -23 ^{o}C and -16 ^{o}C during this period; and the formation of fog which caused less solar radiation absorption during the day. Other non-meteorological factors are the Cache Valley’s small-basin geographical structure which traps air with no big body of water to help the air circulation; motor vehicle emissions, especially during the engine warm-up in very cold weather, which boost incomplete fuel combustion, trapping the emitted particles in the cold air; existence of ammonia gas, a byproduct of livestock manure and urine. This gas reacts with cold air to concentrate small particles. Concentration of PM2.5 (particulates smaller than 2.5 µm in diameter, the most damaging to human health) is monitored in downtown Logan. On January 15, 2004, the maximum concentration reached about 180 µg per cubic meter of air, an astonishing high value compared to the values of 65 and over, indicating a health alert for everyone. The tiny particles in the air have an enormous impact on health, aggravating heart and lung disease, triggering asthma and even death. What can be done to alleviate the wintertime particle concentration in Cache Valley? Some suggestions will be addressed in this article.

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Climate Dependency of Tree Growth Suppressed by Acid Deposition in Northwest Russia

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W. C. Shortle[4], S.W. Bailey[5], D. Varlyguin[6]

Depletion of soil Ca by acid deposition is increasingly being considered as a possible factor in declines of forest health and productivity (Shortle et al., 1997; Schaberg et al., 2002; Bailey et al., 2004). However, limited information on the magnitude and timing of Ca loss has impeded progress in understanding relationships between forest condition and soil changes. Direct evidence of Ca depletion through remeasurement is limited to a few studies, of which only two include data that predate the onset of high acid deposition rates (Johnson et al., 1994; Lapenis et al., 2004). Collection of soil samples and tree cores in 2001-02, 40 km southeast of St. Petersburg, Russia, where soils were previously sampled and archived in 1926 and 1964, has now enabled soil chemistry to be tracked with growth of Norway spruce through the 20th century. Pronounced rooting zone losses of Ca and increases in available Al were measured that were temporally coincident with 1) a decrease in ring-width increment that was unprecedented in the records of these trees, and 2) suppression of climate effects on tree growth. Declining growth appears to be linked to degradation of rooting zone conditions, a finding that has negative implications for productivity and carbon sequestration in forests of northern and eastern Europe, and eastern North America, where decreased Ca availability is likely to be common.

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TECHNICAL SESSION: DRY DEPOSITION ESTIMATES

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

The Impact of Changing NO_x Emissions on HNO_3 Dry Deposition for CASTNET Sites in the Northeastern, Mid-Atlantic, and Midwestern USA

Thomas J. Butler*[1,2], Gene E. Likens[1], Francoise M. Vermeylen[3]
and Barbara J. B. Stunder[4]

Recent reductions in NO_x emissions, largely from reductions in power plant NO_x emissions, are reducing air concentrations of HNO_3 as measured at 21 CASTNET sites located from Maine west to Indiana and south to Virginia. This area has seen the greatest reductions in NO_x emissions when compared with other areas of the USA, and HNO_3 represents 80% of the nitrogen dry deposition component and 25% of the total N deposition, *as measured by the CASTNETNetwork*. It should be noted that gaseous NH_3 deposition is not measured by CASTNET and also may contribute a significant amount to nitrogen dry deposition in some areas.

To quantify the impact of reduced NO_x emissions on HNO_3 we used a random coefficient model to assess the change in NO_x emission impacts on HNO_3 concentration. We regressed HNO_3 concentrations on both total NO_x emissions and non-vehicle NO_x emissions with site and region as random effects. Non-vehicle NO_x emissions represented 45% to 50% of total NO_x emissions. Both types of models produced highly significant relations ($p < 0.001$) between NO_x emissions and HNO_3 atmospheric concentrations.

Source regions for each site or group of sites were based on back trajectories calculated using NOAAs HYSPLIT-4 model. Back trajectories where calculated for each day of the year 2000 and were then clustered to show mean back trajectories. These data were used to estimate source regions of increasing size based on 12-hr, 24-hr and 36-hr back trajectories. Thus, three models were run for each emission type.

Model results show that reducing NO_x emissions within a given source region reduces HNO_3 deposition in a proportionate way, but the relation is not necessarily 1:1. When total NO_x emissions is the independent variable, a 50% reduction in NO_x emissions should lead to a 23% to 25% reduction in HNO_3 concentrations, which in turn should lead to a comparable reduction in HNO_3 dry deposition. If the independent variable is non-vehicle NO_x emissions, a 50% reduction in non-vehicle emissions (which is a 23% to 25% reduction in total NO_x emissions) results in a 14% to 20% reduction in HNO_3 concentration (and deposition).

In summary, the 3 total emissions models (each based on a different sized source region) show that reducing NO_x emissions will reduce HNO_3 concentrations with an efficiency of 43% to 56%. The non-vehicle models show that reductions of NO_x will reduce HNO_3 concentrations (and deposition) with an efficiency of 55% to 90%, depending on the source region used. The errors associated with these estimates range between 15% and 29% for the total emissions models, and 14% for the non-vehicle emissions models.

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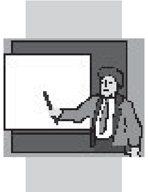

Vegetation as Passive Collectors… Maybe Not

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“Leaf wash”, “throughfall” and “stemflow” are methods for estimating dry deposition based on the assumption that vegetation is a more-or-less a passive collector. That assumption was tested for dry deposition of nitric acid vapor (HNO_3) using a controlled fumigation system. Nitric acid vapor was synthesized by vaporization of aqueous solutions and delivered to fumigation chambers at known concentrations. Four tree species native to western coniferous forests and four shrub species native to the Southern California lowlands were used for these tests. The results showed wide variability in apparent deposition rates among the species under identical atmospheric concentrations. And all species exhibited a saturation point where there was no increase in apparent deposition, as measured by leaf wash, even though exposure to HNO_3 vapor continued. Investigations into the mechanisms of saturation using the stable isotope ^{15}N revealed that 1% to 5% of the deposited nitrogen was absorbed and assimilated into amino acids and proteins. But more importantly, up to 60% of the dry deposited ^{15}N label remained on the leaf surface after washing.

Scanning electron microscopy imagery showed that dry deposition of HNO_3 resulted in microscopic damage to the cuticular surface of leaves. The theoretical chemical interactions between a powerful oxidant, such as HNO_3, and organic compounds, such as those found in leaf cuticles, suggests that chemical oxidation reactions damaged the leaf surface. In these reactions, HNO_3 is chemically reduced to a less water-soluble nitrogen compound (such as NO_2) possibly explaining the poor recovery of dry deposited HNO_3. Extrapolating the experimental results to applications under field conditions, the assumption that vegetation is a suitable passive collector for HNO_3 cannot be supported. These findings suggest that leaf wash, throughfall, and stemflow measurements seriously underestimate dry deposition – depending on the species, environmental conditions and duration of exposure. The results also indicate that dry deposition of HNO_3 may have more serious consequences than increased nitrogen fertility.

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Air-Surface Exchange of Ammonia over Soybean

John Walker*, Wayne Robarge[1], Yihua Wu[2]

Measurements of NH_3 exchange over soybean at a site in eastern North Carolina are presented for the period 6/18/02 through 8/16/02. A modified Bowen-ratio approach is used to calculate bi-directional fluxes using vertical NH_3 gradients and eddy diffusivities for sensible heat. The mean ambient NH_3 concentration during the period is 9.2 $\mu g\ m^{-3}$, which is similar to average summer concentrations measured at a nearby site during previous years. The mean 30-minute average flux for the period is –25.0 ng NH_3-N $m^{-2}\ s^{-1}$ (N = 1504). The average deposition velocity for negative fluxes is 0.49 cm s^{-1} and a compensation point of approximately 5.5 $\mu g\ m^{-3}$ is indicated from periods of flux sign reversal. Measured deposition velocities approach the maximum value allowed by aerodynamic and quasi-laminar boundary layer resistances under conditions of high relative humidity, suggesting that cuticular uptake at night is an important deposition process. While fluxes are primarily directed toward the canopy, emission occurs approximately 25% of the time, most often between 11AM and 4PM. Average emission fluxes are 26 ng NH_3-N $m^{-2}\ s^{-1}$, which is an order of magnitude higher than soil emissions measured at the site via the dynamic chamber method, suggesting that net emissions likely include contributions from both soil and vegetation. These findings indicate that fertilized agricultural systems can be both sinks and sources of atmospheric NH_3, depending on ambient NH_3 concentrations and other environmental conditions. Furthermore, dry NH_3 deposition (21.6 g N $ha^{-1}\ d^{-1}$) at this site is approximately equal to wet NH_4^+ deposition (20.1 g N $ha^{-1}\ d^{-1}$) measured at a nearby NADP site during the same period. Additional measurements will be conducted to determine if these fluxes are spatio-temporally representative of this region. Only then can the relative importance of dry vs. wet deposition of NH_3 to ecosystems in this region be assessed at the watershed scale.

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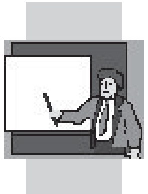

Application of High Resolution, Continuous Instruments at CASTNET Sites

Michael Kolian*[1] and Jonathan Bowser[2]

The Clean Air Status and Trends Network (CASTNET) began routine field measurements in 1987 (as NDDN) with the goal of providing long-term estimates of dry deposition for the United States. Dry deposition is not measured directly but is determined by an inferential approach (i.e., fluxes are calculated as the product of measured ambient concentration and a modeled deposition velocity). CASTNET monitoring design involves collecting atmospheric concentrations of relevant gaseous and particulate species (SO_4^{2-}, NO_3^-, NH_4^+, HNO_3, and SO_2) as integrated weekly averages using a filter-pack sampler (an integrative sampler comprised of multiple in-line filters) with a controlled flow rate [1.5 liters per minute (Lpm) at eastern sites and 3.0 Lpm at western network sites]. Chemical concentrations along with measured meteorological parameters, and site variables (i.e., information on vegetation and land-use) are used as input into a multi-layer resistance model (MLM) to determine flux. Dry deposition (*D*) or flux of chemical species is represented by the product of concentration (*C*) measurements and model estimates of deposition velocities (*Vd*) for the gas or aerosol chemical species of interest (*D = CVd*). Estimates of deposition are made by aggregating modeled, hourly *Vd* to the appropriate time scales (hourly for O_3 and weekly for the filter pack chemical species) and applying the above expression. Deposition velocities for gases and aerosols are estimated at an hourly temporal resolution using the multi-layer model (Clark, et.al., 1997). Important to the characterization of dry deposition is the measurement of chemical concentrations and reliable, routine measurements are necessary for remote locations such as CASTNET sites. Although the filter pack is simple, inexpensive and provides sensitive measurements, it suffers from long sampling duration (7 day) and is subject to bias and uncertainties in species of interest such as HNO_3 and particle NO_3^- (Allegrini et al, 1987; Sickles et al., 1990; Harrison and Kitto, 1990).

Recent advancements in instrument technology utilizing IC analysis have now made it possible to consider robust, high resolution (i.e., hourly) field measurements for CASTNET chemical species. The instrument system, designed to sample gas in the presence of corresponding aerosol particles, is capable of providing hourly concentrations of all current CASTNET analytes as well as ammonia. On-line IC analysis will allow hourly chemical concentration data to be available within 24 hours versus the current CASTNET data schedule of four to six months from date of collection. High resolution measurements will greatly enhance air quality model evaluation for improved regional deposition estimates. The data utilized in conjunction with direct, independent flux measurements (i.e., gradient measurement techniques) can be used to verify deposition estimates at select sites. These measurements will also contribute to improved air quality assessment by allowing more event based tracking of intra-continental pollutant (PM and PM precursors) transport. USEPA plans to implement these instrument systems at three CASTNET/IMPROVE sites (January 2005) for the purpose of evaluating operational performance and network applicability. This will involve an evaluation of the instrument system and collected data according to predetermined performance and acceptance criteria. The goal of this field campaign will be to determine the feasibility of deployment of these instruments at CASTNET sites as next generation monitoring equipment as well as to better understand the current CASTNET data record.

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TECHNICAL SESSION: ESTIMATES OF N AND S DEPOSITION

Session Chair: Viney Aneja, North Carolina State University

An Overview of Wet, Dry, and Total Deposition of Sulphur and Nitrogen in Canada

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The Canadian Air and Precipitation Monitoring Network (CAPMoN) measures major ions in air and precipitation at selected sites across Canada. The measurement data have recently been used to estimate the wet, dry and total deposition fluxes of sulfur and nitrogen at these sites for the five year period from 1988 to 2002. The dry deposition fluxes are calculated using an inferential technique that sets the daily dry deposition flux equal to the product of the measured daily SO_2, particle-SO_4^{2-}, HNO_3 and particle-NO_3^- concentrations times their estimated daily-average dry deposition velocities. The dry deposition velocities are determined using Environment Canada's Regional Deposition Model (RDM).

The dry, wet and total deposition fluxes of sulfur and nitrogen are found to vary considerably in both space and time. As a five-year average, the percentage contribution of dry to total (i.e., wet + dry) deposition of sulfur and nitrogen ranges from 45% to 66% in western Canada and from 17% to 46% in eastern Canada. The annual and seasonal variations of the wet, dry and total deposition fluxes are discussed and compared to those of the US Clean Air Status and Trends Network (CASTNET).

The dry deposition fluxes of nitrogen discussed above are known to be artificially low because they do not include the dry deposition fluxes of NO_2 and PAN (peroxyacetyl nitrate) since neither is measured routinely across the CAPMoN network. Based on field study measurements and special model runs, first estimates have been made of the negative biases in the dry and total deposition flux estimates of nitrogen caused by the omission of these two species. In southwestern Ontario, an area located near the major NO_x emission sources of eastern North America, the missing nitrogen dry deposition flux associated with NO_2 and PAN is estimated to be roughly equal to the combined flux of HNO_3 and particle-NO_3^-. In the more remote areas of eastern Canada, the missing NO_2 and PAN flux is estimated to be 30%-40% of the HNO_3 plus particle-NO_3^- dry deposition flux. These estimates provide a first indication of the major inadequacies of dry deposition monitoring of nitrogen in Canada.

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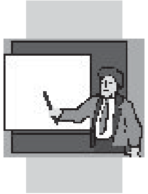

Comparison of Spatial Patterns of Wet Deposition to Model Predictions

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The regional air pollution model, CMAQ, is a “one-atmosphere” model, in that it uses a consistent set of chemical reactions and physical principles to predict concentrations of primary pollutants, photochemical smog, and fine aerosols, as well as wet and dry deposition. The model is being used to develop new federal regulations as well as state implementation plans. As a part of a comprehensive evaluation of CMAQ, this study compares the spatial prediction of yearly total wet deposition of sulfate, nitrate, and ammonium across the country to measurements made by NADP. In order to develop spatial maps of wet deposition it is necessary to interpolate between monitoring sites. However it has been shown that rainfall fields are very spatially discontinuous and non-stationary. Therefore, spatial interpolation of wet deposition is problematic. To overcome this obstacle others have proposed using spatially interpolated precipitation-weighted concentration of the pollutant in rainfall along with a more detailed rainfall field derived from the more dense rainfall networks. We take that idea a step further, by considering two possible sources of data. One is a recently available National Precipitation Analysis. This dataset has been developed by NOAA’s National Center for Environmental Prediction with the Office of Hydrology. The analysis merges two data sources, 3000 automated raingage observations with the digital precipitation estimates from the WSR-88D weather radar. The radar bias is corrected using the gage network. The results are generated onto a 4 km. grid. For this analysis the grid has been relaxed to 36 km to match it to the CMAQ output. The other precipitation source is the NOAA cooperative observer network, with more than 6000 sites in the lower 48 states. The paper will discuss the advantages and disadvantages of these precipitation datasets. The NADP concentration measurements are interpolated to the same grid as the precipitation using a statistical model. Deposition is computed at each cell. The computed spatial fields of total deposition for sulfate, nitrate and ammonium are then compared to the CMAQ model output, and the similarities and differences are noted. Consideration is given to model biases caused by inaccurate precipitation inputs to the model as well as inherent model biases.

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Long-Term Wet- and Dry-Deposition Trends at the Glacier Lakes Ecosystem Experiments Site (GLEES)

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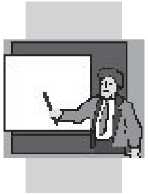
The NADP facility at the Glacier Lakes Ecosystem Experiments Site (GLEES) (WY00), at 3300 m altitude in the Snowy Range of southeastern Wyoming, USA, has recorded wet deposition data since 1987. In 1992 a second facility (WY95) and a dry deposition monitor (CASTNET #169) were installed 2.1 km southeast of WY00, at 3150 m. Co-location of equipment in this manner permits assessment of long-term wet, dry, and total deposition; and spatial variability of wet deposition. Total wet N deposition has remained relatively constant at both NADP sites, with yearly rates of ca. 2.5 kg/ha at WY00 and ca. 2.0 kg/ha at WY95. Regression analysis indicates a relationship (R^2=0.30) between total wet N deposition and precipitation. Wet deposition constitutes 69% of total annual N deposition, with dry deposition accounting for the remainder. However, dry deposition contained only minor amounts of NH_4 and NO_3, the primary components of wet deposition. The majority of dry deposition was in the form of HNO_3. Regression analysis of dry deposition data indicates a small but significant increase over the past 12 years.



Trends in Sulfur and Nitrogen Species at Collocated NADP/NTN and CASTNET Sites

Christopher Lehmann*[1], Van Bowersox[1], Robert Larson[1], and Susan Larson[2]

This presentation expands upon our trend analysis presented at the 2003 Ammonia Workshop by relating concentrations in National Trends Network (NTN) precipitation samples with air quality data reported by the United States Environmental Protection Agency's Clean Air Status and Trends Network (CASTNET). Data from 19 collocated (<10 km) NTN-CASTNET sites were considered from 1990 to 2002. Seasonal mean concentrations of sulfur and nitrogen species were evaluated using the Seasonal Kendall Trend (SKT) test to determine trend direction, statistical significance ($p \leq 0.10$) and seasonal homogeneity ($p > 0.10$).

For NTN sulfate concentrations, all 19 sites showed decreasing trends, with 12 of these trends being statistically significant and homogeneous. For CASTNET gas phase sulfur dioxide concentrations, all but one site showed statistically significant and homogeneous decreasing trends. Only one increasing trend in sulfur dioxide was noted in Wyoming, but this trend was not statistically significant. The ratio of NTN sulfate concentration divided by the CASTNET total sulfur concentration showed an increasing trend at 17 sites; 11 of these trends were statistically significant and homogeneous. This ratio for sulfur species showed a decreasing trend at two sites in West Virginia and Wyoming, but these trends were not statistically significant.

For NTN nitrate concentrations, eight sites showed an increasing trend, but none of these trends were statistically significant. Eleven sites showed a decreasing trend; four of these sites were statistically significant and homogeneous. For CASTNET total nitrate concentrations, 10 sites showed an increasing trend; six of these trends were statistically significant and homogeneous. Nitrate decreased at 9 sites; only five of these trends were statistically significant. The ratio for nitrate (NTN nitrate concentration divided by CASTNET total nitrate concentration) increased at 9 sites, with only one of these increases being statistically significant and homogeneous. The ratio for nitrate decreased at 10 sites; none of these trends were statistically significant.

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Agricultural Ammonia Emissions and Ammonium Concentrations Associated with Precipitation in the Southeast United States

Viney P. Aneja*[1], Dena R. Nelson[1], Paul A. Roelle[1],
John T. Walker[2], and William Battye[3]

Temporal and spatial variations in ammonia (NH_3) emissions and ammonium (NH_4^+) concentrations associated with aerosols and volume-weighted NH_4^+ concentration in precipitation are investigated over the period 1990–1998 in the southeast United States (Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, Mississippi, and Tennessee). These variations were analyzed using an NH_3 emissions inventory developed for the southeast United States and ambient NH_4^+ data from the various Clean Air Status and Trends Network (CASTNET) and the National Atmospheric Deposition Program/National Trends Network (NADP/NTN). Results show that natural log-transformed annual NH_4^+ concentration associated with aerosols increases with natural log-transformed annual NH_3 emission density within the same county ($R^2 = 0.86$, $p < 0.0001$, N = 12). Natural log-transformed annual volume-weighted average NH_4^+ concentration in precipitation shows only a very weak positive correlation with natural log-transformed annual NH_3 emission densities within the corresponding county ($R^2 = 0.12$, $p = 0.04$, N = 29). Investigation into wet NH_4^+ concentration in precipitation consistently yielded temperature as a statistically significant ($p < 0.05$) parameter at individual sites. Positive trends in NH_4^+ concentration in precipitation were evident at NADP sites NC35, Sampson County, North Carolina (0.2–0.48 mg L^{-1}) and KY35, Rowan County, Kentucky (0.2–0.35 mg L^{-1}) over the period 1990–1998.

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TECHNICAL SESSION: DEPOSITION OF MERCURY

Session Chair: David Gay, National Atmospheric Deposition Program

Modeling the Atmospheric Transport and Deposition of Mercury in the U.S. and Canada

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To effectively address the problem of atmospheric mercury deposition to sensitive ecosystems, it is important to know the relative importance of different sources of the contamination. This model-based analysis attempts to provide estimates of such source attribution information.

A special version of the NOAA HYSPLIT_4 model has been developed and used to estimate the atmospheric fate and transport of mercury in a North American modeling domain. The model is a three-dimensional Lagrangian puff model, with detailed simulation of dispersion, deposition, and chemical transformation processes for atmospheric mercury. Spatial and chemical interpolation procedures were used to expand the HYSPLIT_4 modeling results to provide detailed source attribution information.

Overall simulation results include the following: (a) transfer coefficient maps, showing the tendency of mercury emitted throughout the model domain in its various forms [Hg(0), RGM, and Hg(p)] to deposit at locations of interest; (b) comparison of simulated and measured ambient concentrations and deposition fluxes at monitoring sites for model evaluation purposes; (c) estimates of the contribution of each of the sources in a 1999 anthropogenic U.S./Canadian emissions inventory to atmospheric mercury deposition to various locations; (d) maps summarizing the source-receptor relationships for each location; (e) information on the amount of mercury contributed to each location from different distance ranges and from different source categories; and (f) overall budgets for the atmospheric fate of emitted mercury of different forms.

While there are uncertainties in the emissions inventories and in the simulation of mercury's atmospheric fate and transport, model results were found to be reasonably consistent with available deposition measurements. The spatial patterns of source contributions to atmospheric mercury deposition were different for each location studied, but sources up to 2000 km away often contributed significant amounts of mercury. While there were significant contributions from incineration and metallurgical sources, coal combustion was generally found to be the largest contributor to atmospheric mercury deposition to most locations in North America.

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Luncheon

Canadian Acid Rain & Air Quality Issues with a View Towards Transboundary Concerns

Speaker: Dr. Barry Stemshorn
Assistant Deputy Minister
Environment Canada

Biographical Information

Barry Stemshorn is a graduate of McGill University (BSc) and the University of Montreal (veterinary medicine). He joined the public service in 1974, where he spent the first 25 years of his career with Agriculture Canada and the Canadian Food Inspection Agency. From 1988-90 Barry worked for the Inter-American Institute for Cooperation on Agriculture on leave from the Public Service of Canada under an international assignment agreement. Based in Trinidad and Tobago, he developed a network of specialists working in 14 Caribbean countries to overcome non-tariff barriers to trade in agricultural products. Barry spent a year with the Privy Council Office supporting the Cabinet Committee for the Economic Union as Director of Operations, Economic and Regional Development Policy, before taking up his appointment at Environment Canada as Assistant Deputy Minister, Environmental Protection Service.

Monitoring Pilot Project for Wet Deposition of Mercury in Mexico

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The North American Commission for Environmental Cooperation (NACEC) plays a regional role in monitoring, reporting, or assisting the implementations of the regional action plans for persistent organic pollutants (POPs). This has also been the case for the mercury-North American Regional Action Plan (NARAP) where a tri-national agreement on mercury was put forward in 1996. This NARAP is now at the second implementation phase (North American Implementation Task Force on Mercury 2000). Based on the above-mentioned convention, during the first phase of this project the Mercury Deposition Network (MDN) has extended its coverage, by installing two sites in Mexico (see Table). MDN has facilitated this purpose by making available two wet deposition collectors for mercury and offers training and capacity building for Mexican participants. NACEC has assigned funds to assess this initiative through a two-year pilot project. During the initial phases of this pilot project, the requirements and partners to be involved were established and the installations, training and initial operation of the two sites were carried out.

Location and rainfall at the two sites

Site Name	MX01 (Huejutla)	MX 02 (Puerto Ángel)
Location	Instituto Tecnológico Agropecuario No. 6	National Water Commission Radar Station
City	Huejutla	Puerto Ángel
State	Hidalgo	Oaxaca
Latitude	211° 09' 30" N	15° 40’ 16” N
Longitude	981° 22' 14" W	96° 29’ 50” W
Elevation	180 mamsl	110 mamsl
Annual precipitation	1,312 mm	800-1,000 mm

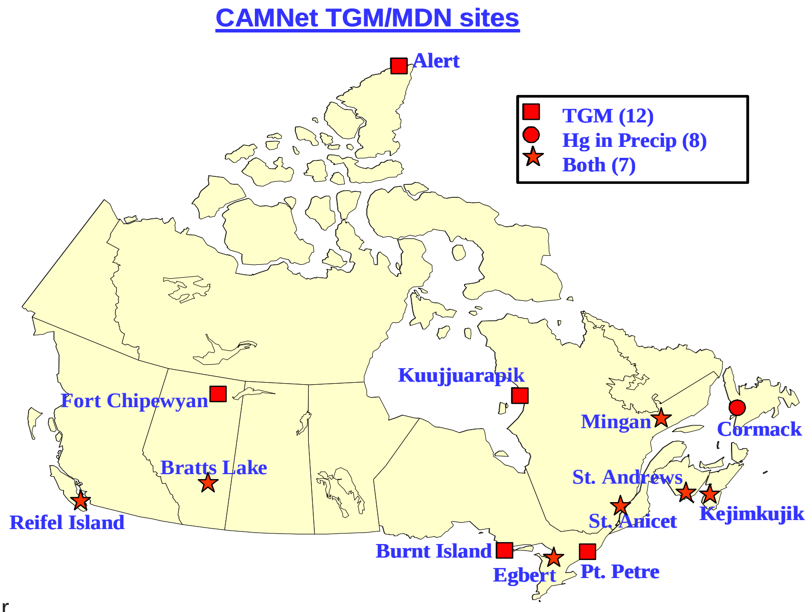
The weekly monitoring of rainwater for analysis of wet deposition of mercury was initiated during the Fall of 2003 at the two sites selected according to the NADP requirements (Bigelow et al. 2001). Elemental mercury is being analyzed at the Frontier Geosciences MDN Hg Analytical Laboratory. Preliminary monitoring data until March 30, 2004 indicate weekly deposition of mercury between 0 and 670 ng m^{-2} wk^{-1} at MX01 and between 0 and 298 ng m^{-2} wk^{-1} at MX02. Average concentrations varied between 21 ng m^{-2} wk^{-1} at MX02 and 126 ng m^{-2} wk^{-1} at MX01. These preliminary records are below the MDN average of 176 ng m^{-2} wk^{-1} for all the stations and Max average of 494 ng m^{-2} wk^{-1} at one of the MDN stations. Also, the data from the Mexican stations are from one semester, only and data from throughout the year and between several years are necessary to draw conclusions about wet deposition of mercury.

An application for certification of the two sites was submitted to the MDN coordinator at Illinois State Water Survey in June, 2004. Furthermore, a proposal for an extension of the monitoring activities to include major ions has been submitted to NACEC in May, 2004. Finally, a suggestion to include deposition programs as national research funding priorities has been submitted to the Mexican authorities. If approved, this should allow including regional data in atmospheric transport models of mercury and other substances.

Recent Results from the Canadian Atmospheric Mercury Measurement Network (CAMNet).

Pierrette Blanchard*[1], Cathy Banic[1], Hayley Hung[1], Stephen Beauchamp[2], Wayne Belzer[3], Frank Froude[5], Brian Wiens[4], Martin Pilote[6], Laurier Poissant[6], Alexandra Steffen[1], Rob Tordon[2]

The Canadian Atmospheric Mercury Measurement Network (CAMNet) was established in 1996 to provide long term measurements of total gaseous mercury concentration and mercury in wet deposition across Canada (Figure 1). The network consists of ten stations. Tekran 2537A analyzers measure total gaseous mercury on a continuous basis at 9 stations. At six stations, mercury in precipitation weekly measurements are made as part of the Mercury Deposition Network (MDN). TGM concentrations do not seem to increase or decrease over time, consistent with Canadian atmospheric mercury emissions in the late nineties. Episodic patterns are seen for rural-affected sites similar to what was found by Kellerhals et al (2003). Mercury in precipitation maxima usually occurred in late spring and throughout the summer. This is most apparent at Kejimkujik Park (Nova Scotia) where mercury in precipitation concentrations always peak in the summer. St. Anicet (Quebec) presented the highest mercury in precipitation levels while Cormack (Newfoundland) and Mingan (Quebec) were lowest. Mercury wet deposition was largest in Kejimkujik Park in all seasons, while the lowest was found for Bratts Lake in the Canadian prairies. Temporal trends derived for selected sites using a digital filtration technique yielded relatively long half-lives of the order of 15-20 years for mercury in precipitation. Preliminary results of combined mercury deposition for Canadian and selected US sites will be presented.



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Estimation and Mapping of Mercury Deposition to Northeastern North America

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While many ecosystem characteristics and processes are known to influence the accumulation of Hg in higher trophic-level organisms, the amount of Hg transferred from the atmosphere to a lake and its watershed are likely factors in the potential risk to biota. Long-term spatial-patterns of atmospheric deposition also influence the extent of Hg accumulation in ecosystem reservoirs such as organic soils and lake sediments. Thus, knowledge of current and previous atmospheric deposition rates, and spatial patterns in those rates, may provide important information for assessing the persistence of risk in ecosystems exhibiting excessive upper trophic-level Hg contamination. Fine spatial-scale patterns such as local variation in vegetation type (receptor surface) and microclimate may be important determinants of the watershed-scale capture of atmospheric Hg.

Data describing atmospheric mercury concentrations in various phases (aerosol, vapor, precipitation) from three observation networks (MDN, EPA-REMAP, Environment Canada) were used to estimate regional surface concentration fields. Statistical models were developed to relate sparsely measured vapor and aerosol concentrations to the more commonly measured concentration in precipitation. Literature review established reasonable bounds for inferring cloud water and RGM concentrations from available measurements. High spatial resolution (30-90m) deposition velocities for different phases (precipitation, cloud droplets, aerosols, and RGM) were computed using Ecosystems Research Group, Ltd.'s High Resolution Distributed Model (HRDM). Net elemental mercury vapor deposition to foliage was estimated using an empirical model and highly spatially resolved estimates of the empirical model's parameters (e.g. forest type, leaf biomass, growing season length).

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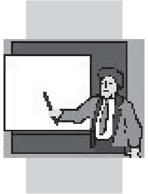

Geochemical Associations of Background Mercury Concentrations in Maine Rivers

John M. Peckenham*[1], Jeffrey S. Kahl[2], Sarah A. Nelson[1] and Barry Mower[3]

Water samples from 58 rivers located throughout Maine were analyzed for mercury and major ion chemistry. Mercury concentrations ranged from below-detection up to 7.01 ng/L with an average of 1.80± 1.29 ng/L. The spatial distribution of mercury revealed localized high concentrations (hot spots). Mercury concentrations were highly correlated with dissolved organic carbon (DOC) and aluminum, and to a lesser extent with copper, lead, and zinc. These correlations changed when the mercury results were partitioned by relative hydrologic flow state or regional geology. Statistically significant differences occurred between hydrologic flow states and by geographical regions. We hypothesize that during high-flow conditions mercury is released from storage in association with DOC. Although most of the mercury in Maine waters is believed to come from atmospheric deposition, the spatial patterns suggest that there may be some localized geological sources. Alternatively, there may be landscape or orographic factors that lead to regions of higher deposition.

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Wet and Dry Deposition of Mercury in Maryland

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Atmospheric deposition is the dominant source of mercury (Hg) to many environments. While it was previously assumed that wet deposition was the dominant atmospheric source of Hg to most locations, some recent studies in polar regions, and over the ocean, have highlighted the importance of dry deposition of reactive (ionic) gaseous mercury (RGHg) in contributing to Hg deposition in remote environments. In addition, it is now clear that RGHg is released by various anthropogenic sources. In remote locations, the source of RGHg is primarily through elemental mercury (Hg^0) oxidation in the atmosphere. In Maryland, early studies focused both on the urban and rural environment and preliminary measurements suggested that measurable concentrations of RGHg existed both in the urban environment (Baltimore) and in a rural location (CBL, a coastal Maryland, USA site). The differences in RGHg mirrored to some degree the differences in wet deposition between these two locations. More recent measurements using the Tekran Hg speciation system have confirmed that elevated levels of RGHg exist at CBL, with occasions where strong diurnal cycles are evident and photochemistry is clearly important, and other occasions where local inputs are likely contributing. In contrast, levels of RGHg were higher and more variable, with little diurnal pattern, in Baltimore. This paper will provide an evaluation of the current and historical data, and a comparison with other datasets, and will examine our current understanding of the factors controlling RGHg formation, and those determining its rate of deposition. In addition to a discussion of dry deposition, the presentation will examine the current and historical datasets for wet deposition of Hg, and for atmospheric Hg speciation, to assess if there has been any measurable change in their concentration over time.

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TECHNICAL SESSION: DEPOSITION OF MERCURY AND OTHER TRACE METALS

Session Chair: Steve Beauchamp, Environment Canada

Measurement of Atmospheric Mercury Species with Manual-Collection and Analysis Methods to Estimate Mercury Dry-Deposition Rates in Indiana

Martin R. Risch*[1], Eric M. Prestbo, Ph.D[2], and Lucas Hawkins[2]

Since late 2000, the U.S. Geological Survey (USGS) in cooperation with the Indiana Department of Environmental Management (IDEM) has been operating five monitoring stations to measure wet deposition of total mercury in Indiana as part of the National Atmospheric Deposition Program Mercury Deposition Network. The IDEM and USGS determined that dry deposition of mercury could be useful information for assessment of mercury inputs to Indiana's aquatic ecosystems. In 2003-04, Frontier Geosciences and the USGS collaborated in the development, implementation, and quality assurance of a program to monitor atmospheric mercury and estimate mercury dry deposition in Indiana.

For the dry-deposition monitoring program, three monitoring stations are operated simultaneously in northern, central, and southern Indiana, adjacent to the mercury wet-deposition monitoring stations. Timer-activated air-sampling systems run for one 12-hour sampling period a week, on a rotating schedule. Similar to the wet-deposition monitoring, a manual-collection and analysis method is being used. The atmospheric-mercury samples are removed soon after the completed sampling period and are shipped to the laboratory for analysis.

The air-sampling system contains a three-part sampling train to isolate three atmospheric-mercury species. Reactive gaseous mercury is retained in a potassium-chloride-coated quartz annular denuder. Particulate-bound mercury is retained in a quartz filter holder. Elemental mercury is caught in a two-stage trap of gold-coated quartz grains. Laboratory analysis is done by thermal desorption and cold vapor atomic absorption spectrometry. On-site meteorological data are collected for use in an inferential model to estimate a vertical-deposition velocity and the dry-deposition rates of each mercury species.

Preliminary results of mercury dry-deposition monitoring during 7 months in 2004 in Indiana will be presented. Atmospheric-mercury concentrations and dry-deposition rates will be described and compared with mercury wet-deposition rates. The methods for the Indiana monitoring program as a prototype for other stations in the Mercury Deposition Network in North America will be discussed.

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Mercury Deposition in the Loch Vale Watershed in Rocky Mountain National Park, Colorado, 2002-2003

M. Alisa Mast*[1], Donald H. Campbell[1], David P. Krabbenhoft[2], and George P. Ingersoll[1]

Mercury (Hg) was measured in summer bulk precipitation and seasonal snowpacks in the Loch Vale watershed in Rocky Mountain National Park, Colorado, during 2002-2003 to quantify atmospheric deposition of Hg to high-elevation ecosystems. During the snow-free season (May–October), a bulk precipitation collector was operated in an open area adjacent to the Loch Vale NADP station at an elevation of 3,159 m. Weekly samples were collected from a collector consisting of a polycarbonate funnel connected to a PETG collection bottle with Teflon tubing. To estimate winter deposition, full-depth snowpack samples were collected in early April, just prior to the onset of snowmelt, using Teflon bags and polycarbonate shovels. Concentrations of total Hg in bulk precipitation samples collected at Loch Vale during the study period ranged from 2.6 to 36.2 ng/L, similar to the range of 1.8 to 31.0 ng/L reported for weekly samples collected at the Buffalo Pass Mercury Deposition Network (MDN) station during the same period. The Buffalo Pass station is located in the Zirkel Wilderness approximately 90 km west of Loch Vale at a similar elevation (3,234 m). Mercury concentrations in precipitation at both sites had similar seasonal patterns with concentrations that were 3 to 4 times higher during summer months compared to winter months. Higher concentrations in summer may be due to more efficient scavenging of particulates by rain compared to snow or to seasonal changes in levels of reactive gaseous Hg in the atmosphere. Snowpack samples collected during the study indicated Hg concentrations in forested areas were typically twice those measured in open areas suggesting that dry deposition of Hg to the canopy also is an important source of mercury to high-elevation ecosystems. Annual volume-weighted mean (VWM) concentrations at Loch Vale were 12.8 ng/L in 2002 and 9.0 ng/L in 2003, which were higher than annual VWM concentrations at the Buffalo Pass MDN station (6.8 ng/L in 2002 and 6.5 ng/L in 2003). One possible explanation is that the Loch Vale samples represent bulk deposition whereas the MDN collector captures wet deposition only. Annual deposition of Hg at Loch Vale was 8.3 $\mu g/m^2$ in 2002 and 7.3 $\mu g/m^2$ in 2003. Annual deposition of Hg at Buffalo Pass was similar at 6.0 $\mu g/m^2$ in 2002 and 7.6 $\mu g/m^2$ in 2003. On an annual basis, less than 20% of atmospherically deposited Hg was exported from Loch Vale in streams indicating that the terrestrial environment is a net sink of atmospherically deposited Hg or that significant revolitalization of Hg from soils is occurring.

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Determination of Arsenic, Selenium, and Various Trace Metals in Rain Waters

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Human industrial activities have substantially increased trace metal concentrations in the atmosphere and in atmospheric deposition. In addition, many trace metals are more soluble under the acidic conditions found in precipitation, which enhances their bioavailability. If the concentrations are too high, many of the trace metals can become harmful to human health through the consumption of drinking water and/or aquatic organisms. Trace metals from precipitation can also accumulate in surface waters and soils where they may cause harmful effects to aquatic life and forest ecosystems. Setting up a method for collecting, handling, and analyzing rainwater samples for trace metals can be useful for determining long-term and geographic trends. However, it can be difficult to consistently collect ultra-clean samples over large geographic regions. Furthermore, once collected, it can be expensive and cumbersome to preserve and analyze samples for all of the metals of interest. Lending to the expense of analysis, samples may have to be analyzed several times by different methods in order to attain the low detections limits required to quantify low concentrations often found in rainwater samples. For instance, the concentrations of As and Se in rainwater are generally less than 50 ng/L and therefore the use of ICP-AES is totally ruled out while HG-AFS instead of conventional ICP-MS has been necessary. Unfortunately, this used to result in increased cost for the determination of the whole suite of trace metals since it was necessary to prepare and analyze rainwaters for As and Se separately from the rest of the metals. We have recently developed a method to determine a variety of elements including As and Se in a single run to decrease the cost of this analysis significantly. The new method uses an ICP-MS instrument equipped with a Dynamic Reaction Cell to not only remove interferences that may cause false positives but also provide better signal to background ratios for improved detection limits. In this study, rainwater samples are collected in pre-cleaned sampling trains made of high-density polyethylene. A 126-mm funnel and a 1-Liter bottle are removable pre-cleaned parts that get replaced during each collection event. In the lab, samples are preserved with HNO_3/HF and heated overnight. Since there are no rainwater reference materials with certified trace metal concentrations, the method was validated for As and Se by comparing results from HG-AFS and ICP-MS. The method detection limits obtained by this new method was 0.009 and 0.015 ug/L for As and Se, respectively. With this new method, the lowest detection limits were obtained for Cd and Co at 0.003 ug/L while the highest method detection limit obtained was for Zn at 0.038 ug/L. While we are constantly trying improve upon these detection limits, this method is used for the monitoring of trace elements in wet deposition samples collected at various sites throughout the country.

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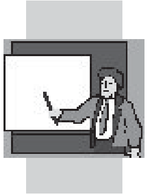

Hg/^{210}Pb Correlations In Precipitation and their Use in Apportioning Regional and Global Components of Current and Historical Hg Deposition

Carl H. Lamborg*[1], William F. Fitzgerald[2], Daniel R. Engstrom[3] & Prentiss H. Balcom[2]

In a paper published in 2001, Lamborg et al. reported good correlations between total Hg and the naturally occurring, particle-tracing radionuclide ^{210}Pb in rainwater from northern Wisconsin and the equatorial Atlantic Ocean. Subsequently, results from other remote locations have indicated that this may be a wide spread phenomenon. The precise cause of this correlation is not known, but suggests an analogy between the ^{210}Pb system (solid ^{226}Ra→gaseous ^{222}Rn→particulate ^{210}Pb→precipitation ^{210}Pb) and Hg chemistry in the atmosphere (gaseous Hg^{o}→gaseous Hg(II)→particulate Hg(II)→precipitation Hg(II)).

Whatever the cause, the rainwater correlation of Hg and ^{210}Pb offers a potential tool for discerning regional and global influences on local Hg depositional fluxes. For example, sites which receive little local/regional Hg should show Hg/^{210}Pb ratio values in precipitation similar to those observed at remote locations, while sites that receive Hg deposition of a more localized nature should show ratio values greater than those of remote locations. In effect, the application of ^{210}Pb as a normalizing tracer of particulate scavenging should remove the issue of site-to-site variation in climatology (rain depth, frequency, temperature, etc.) and permit direct comparison of sites from widely differing locations.

We are currently operating a 8 site Hg/^{210}Pb precipitation network within the NADP/MDN network to explore the utility of this new geochemical tool. The sites for this experiment include 7 existing MDN sites (Seattle; Lamberton and Marcell, Minnesota; Andytown and ENRP, Florida; Acadia National Park and Cormack, Newfoundland) as well as in a newly established site not part of the MDN network at Glacier Bay National Park (S.E. Alaska). These sites will operate for about 2 years and yield an unprecedented set of Hg and ^{210}Pb comparisons. Concurrently, we are collecting and analyzing sediment cores from undisturbed lakes from continental upwind (Glacier Bay, Alaska) and downwind (Newfoundland) locations to assess the impact of continental/regional-scale sources on the anthropogenic enhancement of Hg deposition in the last few centuries. Similar measurements made in Nova Scotia and New Zealand suggest regional enhancements in the deposition of Hg to maritime Canada (and presumably much of eastern North America) in the last 150 years. Potential causes of this enhancement (regional Hg sources or regional oxidant formation) will be explored. Preliminary results from precipitation and sediment work will be presented.

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Atmospheric Wet Deposition of Trace Elements to a Suburban Environment near Washington, D.C., USA

Karen C. Rice*[1] and Kathryn M. Conko[2]

During 1998, wet deposition from Reston, Virginia, USA, a suburb of Washington, D.C., was collected and analyzed for anion and trace-element concentrations. Wet-deposition samples were retrieved every two weeks from an automated collector; trace-element clean sampling and analytical techniques were used. Reston, approximately 26 km west of Washington, D.C., is a developed, densely populated (1,116 people/km^2) area, and samples from this site provide an indication of local anthropogenic effects on wet-deposition quality.

The annual volume-weighted concentrations of As, Cd, and Pb were similar to those previously reported for an undeveloped, more remote site on Catoctin Mountain, Maryland (70 km northwest), suggesting a regional depositional pattern for these elements. At the suburban site, concentrations and depositions of Cu and Zn nearly were double those at the undeveloped site. Both of these elements are contained in brake linings and tires; therefore, resuspension of Cu and Zn particulates from roadways likely is a local source of these elements in atmospheric deposition. Patterns of higher deposition of Cl^- during the winter months, when roads are salted, is an additional indication that resuspension of particulates from roadways is affecting wet-deposition quality in this suburban environment.

Analysis of digested total (dissolved plus particulate-associated) trace-element concentrations in a subset of samples showed that a larger portion was composed of refractory elements at the suburban site than in undeveloped areas. Whole-water analyses, therefore, may be more precise indicators of total deposition mass of trace elements than the acid-leachable fraction of samples at sites affected by local anthropogenic sources.

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POSTER SESSION
(IN ALPHABETICAL ORDER BY FIRST AUTHOR LISTED)

Estimating Potential Acid-Rain Induced Base-Cation Depletion Economics For Nova Scotia and New Brunswick

V. Balland[1], P.A. Arp[1], E. Hurley[2], I. DeMerchant[2], and Y. Bourassa[3]

Acid-rain induced base-cation depletion (mainly Ca^{2+} + Mg^{2+} + K^{+}) in forest soils likely interferes with overall forest health and growth. Impacts of sustained atmospheric S and N deposition would be particularly severe in areas where the soil-available Ca, Mg and K supply is already growth limiting. Therefore, it is important to quantify and map rates of base-cation depletion across the potentially impacted forest terrain. Quantifying these rates allows one to evaluate the potential base-cation replacement costs. These costs--in turn--provide a fairly robust estimate of the economic burden that comes with not sufficiently reducing acid-producing air pollution. This poster outlines this cost-evaluation process, based on two scenarios: maintain present levels of S and N deposition (“business-as-usual”), or cut these levels by one half by Year 2010, for Nova Scotia and New Brunswick as case studies.

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Variety Within Unity:
Enhancement Options Add Versatility to Standard, Field Proven Precipitation Collectors

John S. Beach, Jr., Vice President
N-CON Systems Co., Inc.
Crawford, GA 30630

The validity of results of long-term precipitation networks depends on the reliable performance of unattended sample collectors. Field changeable options enhance the value of standard collectors.

Some of the options include:
- Choice of sample train
- Temperature control of sample storage
- Interface with data loggers and rain gages

This poster describes the development of field changeable temperature controls, interface options for data loggers and various sample train configurations to meet specific analytical requirements of the NADP/NTN, MDN and other precipitation chemistry networks, based on technical requirements and user “wish lists”.

Description of an Automated Instrument for Measurements at CASTNET Sites

Jon J. Bowser*, Rene P. Otjes[1], Jan van Burg[2], & Michael Kolian[3]

CASTNET is a well established, long-term environmental monitoring network consisting of nearly 90 sites spanning the United States that measure ambient concentrations of aerosols and gases. The network is designed to measure weekly average concentrations in order to derive dry deposition estimates from seasonal and annual average concentrations over many years. Currently, particles and selected gases are collected by passing air at a controlled flow rate through an open-face, three stage filter pack. Ambient measurements include SO_2 and HNO_3, and particulate SO^{2-}_4, NO^-_3, NH^+_4, Cl^-, Ca^{2+}, Na^+, K^+, and Mg^{2+}.

CASTNET has implemented a program to evaluate emerging technically and scientifically advanced measurement techniques and to ultimately determine the feasibility of enhancing the monitoring capacity of CASTNET through use of this instrumentation. The intent is to replicate existing CASTNET measurements by utilizing different instruments and techniques as well as to expand the range of measured analytes at selected CASTNET project sites to include. These measurements will be made with a time resolution of one hour.

The Applikon Monitoring Instrument for Aerosols and Gases (MARGA) has been selected for deployment at three CASTNET sites, which are located in inherently different geographic regions (east, west, and central United States). The different geographic locations will allow comparison of the effects of climate, topography, and regional chemistry on instrument performance. The MARGA is based on similar instruments developed at the Energy Research Center of the Netherlands (ECN). Gas sampling is accomplished with a wetted, rotating annual denuder (WRD) while aerosol sampling is accomplished using a steam-jet aerosol collector (SJAC). Analyses are accomplished using two Metrohm 761 ion chromatographs (ICs). One IC is used for analysis of gas and particle phase anions and the other is used for analysis of ammonia and particle cations. The Metrohm cation analysis method does not require the use of a suppressor. Fluid handling is accomplished with syringe pumps. The instrument is designed for reliability and minimal maintenance.

The following is a summary of the Applikon MARGA operational parameters:

Sample flow rate: 16.7 actual liters per minute (Lpm)
Particle species measured: SO^{2-}_4, NO^-_3, Cl^-, NH^+_4, Mg^{2+}, Ca^{2+}, K^+, and Na^+
Gas species measured: SO_2, HNO_3, NH_3, HCl, and HONO
Detection limits: ~ 0.05 $\mu g/m^3$ for all species at 1-hour resolution
Quality assurance: internal standards
Unattended operation: 7 days with quarterly maintenance intervals
Weekly fluid consumption: 8.5 gallons

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Concepts for Establishing a Network to Detect Trends in Mercury in Aquatic Ecosystems

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With several proposed regulatory actions to reduce mercury emissions under consideration in the United States (see for example, http://www.epa.gov/mercury/), reductions in atmospheric mercury loading to aquatic ecosystems are likely. Decreases in mercury bioaccumulation are expected, especially in ecosystems where atmospheric deposition is the dominant mercury source. There will likely be a considerable lag time in some ecosystems between reduced mercury inputs and reduced mercury in gamefish. There is considerable uncertainty, however, in predicting temporal and spatial responses to mercury-emissions reductions among varied ecosystem types across North America. Absent a comprehensive new initiative to monitor trends in aquatic ecosystems, better coordination of existing state and federal programs could produce scientifically sound and policy relevant network for the purpose of evaluating ecosystem response to emission reductions. A coordinated network of long-term monitoring sites would generate powerful data sets to assess mercury trends in key ecosystem components (precipitation, stream or lake water, and fish tissue). Collocating stream and lake sites with existing National Atmospheric Deposition Program / Mercury Deposition Network is a critical collaboration that would yield nationally consistent mercury deposition data. A framework for water and fish sampling frequency can be tailored to specific site types (stream or lake) and site characteristics, and allow integration with ongoing monitoring programs

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Trace Metals in Wet-Deposition: New Initiative for the Mercury Deposition Network

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Trace metals measurements in wet-deposition, in addition to mercury, are a critical component in the determination of the source, transport and input to aquatic and terrestrial ecosystems. Recent legislation such as the Total Maximum Daily Load (TMDL) and Toxic Release Inventory (TRI) has further demonstrated the need to measure trace metals in wet deposition. In 1998, the Mercury Analytical Lab (HAL) began a new initiative to develop this capability for the Mercury Deposition Network (MDN). The focus of this new initiative was to add the US EPA priority trace metals Sb, As, Be, Cd, Cr, Cu, Pb, Ni, Se, Ag, Tl, Zn in addition to Hg. For sites where source-receptor chemical-mass-balance studies are to be done, additional metals such as V, Mn, Fe and Al to name a few, can be added to the list. With the advent of US EPA 1600 Series analytical trace metals techniques, previously difficult trace metals measurements have been improved sufficiently, to more accurately and precisely measure the low concentration ranges (ppt) expected in wet-only deposition. A trace metals clean sample train and modified second chimney of the MDN Aerochem collector was custom designed for this new initiative. The trace metals sample train and MDN Aerochem modifications will be described in detail. As a first step, these new techniques were applied to measure trace metals at a select number of MDN sites throughout the network.

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Mapping Critical Loads and Exceedances for Eastern Canada

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This poster informs about mapping process and latest maps depicting pattern of critical soil acidification loads and related exceedances across eastern Canada. Two approaches have been used: one that assigns the critical soil acidification parameters to the attribute files of existing ecological land classification data layers, and one that examines well-studied sites, such as those of the Acid Rain National Early Warning System (ARNEWS). The maps show that areas impacted by historical acid deposition are mostly located in southern Ontario, southern Quebec, and Nova Scotia, in areas where the rate of soil weathering is slow on account of weather-resistant soil substrates. On uplands, forests would be most affected. Forests on these locations have shown decline symptoms that appear to be correlated with the extent of the local soil acidification exceedance, as calculated.

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Equivalency Evaluation of Two Ion Chromatography Methods and Equipment

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The National Atmospheric Deposition Program/Central Analytical Laboratory (NADP/CAL) uses two DX-500 Dionex Ion Chromatographs, purchased in 1995, for analysis of sulfate, nitrate, and chloride in precipitation samples. The current equipment utilizes a sodium bicarbonate/sodium carbonate ($NaHCO_3$/Na_2CO_3) eluent, AS4A columns, and a 250 mL sample loop. Two new Dionex ICS-2000s were purchased in June 2004 to perform similar analytical work. A Potassium Hydroxide (KOH) method and AS18 columns were used with the new equipment. Advantages of the new equipment include a smaller sample loop (25 mL), automated Eluent Generation, and heated column compartments. Both instruments use conductivity detection and AutoSuppression technology. Before using the KOH method and the new equipment for NADP sample analysis a comparative study must be done. A side-by-side comparison was conducted to evaluate the differences and to minimize a step-function change in the data reported. NADP/CAL Quality Control samples and External Quality Assurance samples were analyzed to determine method comparability. Preliminary data along with statistical analysis are presented.

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Determination of Total Phosphorus in Precipitation Samples by Inductively Coupled Plasma-Optical Emission Spectroscopy

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The aim of this study was to determine if total phosphorus in precipitation samples could be measured by inductively coupled plasma optical emission spectroscopy (ICP-OES). The CAL measures soluble orthophosphate, commonly referred to as “reactive phosphorus” in filtered (0.45 um) samples for the NTN and in unfiltered samples for the AIRMoN. Orthophosphate is measured colormetrically using the Berthelot reaction method by flow injection analysis (FIA). Total phosphorus measurements require a predigestion step that greatly increases analysis time. Traditionally, the colorimetric method for orthophosphate provides lower detection levels than ICP-OES methods; however, the high temperature of the argon plasma used in ICP-OES could eliminate the need to hydrolyze and digest samples prior to colorimetric analysis. In order to enhance ICP-OES sensitivity, a “polyboost” setting that purges the optics with argon gas at about twice the rate for normal analysis to minimize spectral interferences in the UV region was used. A method was developed which yielded a detection limit of 0.009 mg/L for phosphorus, which is consistent with FIA method detection limits. Calcium and sodium have been reported to interfere with phosphorus measurements with ICP-OES. Matrix spikes at the 25th, 75th, and greater than 99th percentile levels of these analytes in precipitation samples were performed and no interferences were observed.

A New Precipitation Collector for use by the National Atmospheric Deposition Program: Results of Phase I Field Trial

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The current precipitation collector (PC) used by the AIRMoN, MDN and NTN was first developed in the early 1970s after a DOE-Health and Safety Lab design. The PC exhibits several performance characteristics which suggest improvements; particularly: insensitivity to light snow, potential contamination from raindrop splash and poor driving strength. In addition, the PC design pre-dates micro-processor controllers and their potential for increased power efficiency, durability, data transfer utility and user customization.

The NADP Program Office has operated a side-by-side high resolution intercomparision among 3 candidate and the current NADP PC.

This poster will detail the results of 24 grouped events from the 4 PCs using the NADP/AIRMoN protocol (event based, refrigeration until analysis for inorganic constituents).

In general; differences among the 4 PCs seem a function of sensor design (optical interference and/or contact grid), drive motor response and chassis mass. For central Illinois, concentration differences ranged upwards to 25% on an event basis, especially for snow conditions. In all but 2 events (where raindrop splash may have effected the loading into the NADP PC) the candidate PCs show higher analyte concentrations. Estimates of potential changes in deposition results for NTN will be discussed.

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Water Chemistry Changes in New Brunswick (Canada) Lakes Relative to Reductions in Acid Precipitation

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In New Brunswick (NB), Canada, two groups of lakes, thirty-nine located in southwestern NB and forty-six in north-central NB, were periodically sampled between 1986 and 2001 in order to examine changes in water chemistry relative to emission controls and reductions in acid deposition. The lakes are located in areas of the province that are considered to be acid sensitive due to the type of bedrock. To look at changes in wet deposition over time, NB has maintained a (regionally representative) precipitation monitoring network since the early 1980's. Deposition of sulfate (SO_4^{2-}) has generally been decreasing since the 1980's; however, nitrate (NO_3^{2-}) deposition is only slightly lower now than in the 1980's and the deposition levels have remained fairly steady from 1991 to 2003. Hydrogen ion (H^+) deposition had generally been decreasing since the 1980's but has increased again in 2002 and 2003. The deposition of calcium (Ca^{2+}) has slightly decreased since the 1980's, with larger decreases in southern NB than in northern NB.

The lake chemistry data were evaluated by dividing the two groups of lakes into four clusters based on their acid neutralizing capacity (ANC). The clusters for the southwestern and north-central lakes were different due to the fact that the north-central lakes in general have a much higher ANC than the southwestern lakes. For the southwestern lakes, only 20% of the lakes had an average ANC of 40 μeq/L or greater and maintained an average pH of greater than 6 over the study period, whereas, 91% of the north-central lakes had an average ANC of greater than 40 μeq/L and the pH has consistently remained above 6.0. In general, the southwestern lakes showed an overall decrease in sea-salt corrected (SSC) SO_4^{2-} between 1986 and 2001. Between 1986 and 1993, the lakes showed decreases in Ca^{2+}, pH, ANC, and total organic carbon (TOC) followed by increases between 1993 and 2001. For the north-central lakes, SSC- SO_4^{2-}, Ca^{2+}, and ANC generally declined between 1984 and 1998, and increased again by 2001. TOC and H^+ showed the opposite trend, they generally increased between 1984 and 1998 and decreased in 2001. Although acid deposition in NB has generally declined and some lake chemistries are beginning to show signs of acid recovery, eighty percent of the southwestern lakes remain acid sensitive and have little buffering capacity and low calcium, pH and ANC. If the current trend of increasing H^+ deposition continues, these acid sensitive lakes may decline further. On the other hand, most of the north-central lakes appear to have a level of ANC that has been sufficient to buffer the historical level of acid loading.

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Acid Rain and Storm Direction

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The burning of fossil fuels is a major cause of providing gases for acidic precipitation. Sulfur and nitrogen are oxidized to sulfur dioxides and nitrogen oxides which when hydrated form the acidic precipitation that falls upon our buildings, artworks, and biota. The effect of acid precipitation on the environment has contributed to the detriment of certain aquatic life in water systems in many parts of the world. Storms generally follow a directional pattern that moves eastward from the source. The Northeastern States in the United States and parts of Canada have traditionally suffered from acidic precipitation. This study monitored the amounts and pH of rainstorms at a site in Fredericton, New Brunswick, Canada. The extent of acidic precipitation was monitored for a five-month period from March to August 2003 as part of a Fulbright Fellowship. Rainfall data was collected daily, and the amounts and pH of the samples determined using a Wellman Rain gauge and Orion pH meter respectively. Most collected samples had pH values near 5.7, the pH of water equilibrated with carbon dioxide. Several storms each month had pH values below the equilibrium standard with some storms having pH values of 4.5 or less. This acidic precipitation indicates a continuation of pollution events occurring during the monitoring period. NOAA Storm Backtracking will be used to follow the path of the precipitation event to its trajectory over the land.

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NADP Precipitation Samples Track 2004 U.S. Dust Storm

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In late February 2004, a strong storm moved across the U.S. from the Southwest. The storm generated a large dust cloud that was tracked using hourly nation-wide NEXRAD composites. Calcium levels in NADP- National Trends Network (NTN) precipitation samples obtained for that period tracked well with the path of the storm. A rain sample collected at the Illinois State Water on February 20th also contained a large amount of fine brown dust from this storm as it crossed central Illinois. Electron micrographs of the particulate material in this sample were performed and revealed a bimodal size distribution of 1-2 µm and 15-20 µm particles. In addition to the regular analyses that the CAL performs, these samples were also analyzed for cadmium, chromium, cobalt, copper, iron, manganese, nickel, strontium, vanadium and zinc by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES). NTN protocol was followed and samples were filtered (0.45 µm) prior to analysis but were not acidified. All of the samples had traces of copper, most had traces of manganese, zinc, and strontium and some had traces of iron. A strong correlation was apparent between pH and the amount of copper and iron found in the samples.

Ammonia and Nitric Acid Measurements in the Midwest

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Ammonia is the primary basic gas in the atmosphere, and plays a critical role in the formation of fine particles through its reactions with nitric acid and sulfuric acid. Despite its importance in atmopheric chemistry, measurements of gas phase ammonia have not been made routinely by any national network. To fill this gap, the Midwest Regional Planning Organization (MRPO) and the Central Regional Air Planning Association (CenRAP[d1]) undertook a one-year sampling study of ambient ammonia at 10 sites, beginning in October 2003. The sites were chosen to represent regional background concentrations, with the exception of one urban site in Detroit. Other species measured as part of the ame study are nitric acid, sulfur dioxide, and particle sulfate, nitrate, and ammonium. The sites are collocated with IMPROVE monitors and sample on a 1/6 day schedule so that each ammonia sampling day coincides with an IMPROVE sample.

The samplers consist of a Teflon-coated cyclone to remove particles greater than 2.5 um, two denuders (one for acid gases, one for ammonia) in series, followed by a Teflon filter and a nylon filter (to capture nitric acid lost from particulate nitrate on the Teflon filter). Two sites are using a Rupprecht & Patashnick Model 2300 automated speciation sampler to make the same measurements. Additional measurements of ammonia and nitric acid are being made at one site (Bondville, IL) by a semi-continuous ion chromatograph, and continuous measurements of ammonia at the same site are being made by photoacoustic spectroscopy.

This paper presents preliminary data from this ammonia network. Spatial and seasonal variability in ambient ammonia and nitric acid are compared, including urban and rural differences. The continuous and semicontinuous of ammonia are compared to each other and examined for diurnal variations.

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Atmospheric Mercury in the Chesapeake Bay Region

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Modeling studies have suggested that the Chesapeake Bay region is subject to relatively high mercury deposition, owing to the prevalence of large mercury sources in the region. While there is known concern for mercury contamination of fish in freshwater impoundments in the Bay's Watershed, there is less known about the mercury–to methyl-mercury conversion processes in the estuary and its potential significance. It is believed that estuaries (as well as coastal wetlands and salt marshes) can be significant producers of methylmercury as conditions in these locations favor anaerobic bacteria that facilitate methylation. Atmospheric deposition is thought to be a significant loading pathway of mercury to the Chesapeake Bay. A goal of this study is to further our understanding of the amount, spatial and temporal variations, and sources of atmospheric deposition of mercury to the Bay. Continuous measurements of the atmospheric concentrations of Reactive Gaseous Mercury (RGM), Particulate Mercury (Hg(p)) and Elemental Mercury (Hg(0)) have been made at two coastal sites on the Eastern Shore of Maryland for two months during the Summer of 2004. Event-based precipitation samples also have been collected during this time period and analyzed for mercury. At one of the sites (Oxford), continuous measurements of the ambient air concentrations of SO_2, O_3, and CO were also carried out. The second site (Wye) is an NADP and AIRMoN-dry site with a corresponding range of additional measurement data. Meteorological data were collected at both sites. Preliminary results indicate relatively high levels of RGM in the region, consistent with the earlier modeling studies. These and other study data will be presented and discussed. Ultimately, the measurements will be used for the evaluation and refinement of an existing HYSPLIT-based atmospheric mercury fate and transport model.

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Trends in Wet and Dry Deposition Component Ratios for Sulfur and Nitrogen

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The Clean Air Act Amendments of 1990 (CAAA) mandated significant reductions in sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions from electric power generating plants. In response to the CAAA, the Environmental Protection Agency (EPA) established the Clean Air Status and Trends Network (CASTNET) in order to track the results of emissions reductions. Developed from the National Dry Deposition Network (NDDN), CASTNET is a long-term, national air quality and acid deposition monitoring program. It collects data on the dry deposition component of total acid deposition (the sum of wet and dry deposition), ground-level ozone, and other atmospheric pollutants from rural, regionally representative monitoring sites.

During the last fifteen years, CASTNET's main objectives have been to monitor the status and trends in regional air quality and deposition; collect data; and assess and report geographic patterns and long-term, temporal trends in ambient air pollution and acid deposition. As these objectives have been implemented, one question that has been considered is whether the sulfur and/or nitrogen dry to wet deposition component ratios have changed during the last fifteen years.

CASTNET data on dry deposition is combined with the National Atmoshperic Deposition Program's (NADP) data on wet deposition in order to ascertain total deposition. As a result of the policies implemented under Title IV of the CAAA, large reductions in emissions, primarily of sulfur dioxide emissions, have occurred. These resulting reductions may have changed the observed chemical concentrations and relative contribution to the total of any particular species. CASTNET and NADP data will be analyzed temporally (i.e., before and after implementation of Title IV), seasonally (i.e., winter vs summer), and spatially (i.e., northeast vs southeast regions) to determine trends within the dry to wet component ratio for sulfur and nitrogen deposition. This is critical, as it will help us to understand the interaction between dry and wet deposition components and how they should be combined to measure total deposition.

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Filling a Gap: MDN Stations VA-08 (Culpeper) and VA-28 (Shenandoah National Park–Big Meadows) in Virginia

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The Mercury Deposition Network (MDN) now consists of nearly 100 stations in the U.S. and Canada. Most MDN sites are in the eastern third of the U.S. and adjacent areas of eastern Canada, where projected rates of atmospheric mercury deposition are relatively high, due to prevailing weather patterns and the concentration of coal-burning power stations in this region. Nonetheless, prior to 2002, there were no operating MDN sites in the states of Virginia, Maryland, Delaware, and West Virginia, constituting a significant gap in the network. To help fill the gap, two new stations in Virginia, the 88th and 89th stations in the MDN network, began operation in October/November, 2002. Station VA-08 (lat. 38.4222; long. –78.1044) near Culpeper, is sponsored jointly by the U.S. Geological Survey and George Mason University. Station VA-28 (lat. 38.5225; long. –78.4358), was added to an existing National Atmospheric Deposition Program site at Big Meadows in Shenandoah National Park, and is supported by the National Park Service. These MDN sites will provide information on background mercury levels, primarily from sources to the west, in the vicinity of the Washington-Baltimore-Richmond urban corridor. Data from station VA-28 will also be used as a reference for ecological and water-quality studies within Shenandoah National Park. The two stations are within 30 km of each other, making them among the closest of any two sites in the MDN, but differ in elevation by about 900 m.

Preliminary 2003 quarterly volume-weighted average mercury concentrations are consistently higher at VA-08 (5.19, 9.92, 10.54, 6.17 ng/L) than at higher elevation site VA-28 at Big Meadows (3.60, 8.72, 7.50, and 4.86 ng/L), for all four quarters of 2003. These results suggest an elevation influence to mercury deposition in the region that needs to be confirmed over a longer period of observation. The 2003 quarterly results for VA-08 are more like those at next nearest (more than 200 km away) sites in southern Pennsylvania, such as PA-13, PA-00, and PA-47, than they are to VA-28. On a weekly basis, however, both Virginia sites commonly show corresponding mercury concentration highs or lows. For example, both VA-08 (32% of average) and VA-28 (36% of average), showed pronounced mercury lows relative to 3rd quarter 2003 weighted average concentrations, for weekly or event samples taken after Hurricane Isabel (Sept. 18, 2003). These results likely reflect: 1) the origin of the hurricane in the Atlantic, far from anthropogenic sources of mercury, and 2) dilution of mercury in the atmosphere by the large amount of precipitation.

By the end of 2005, we expect to have sufficient data for mercury to begin to assess regional trends, and make meaningful comparisons among stations in the mid-Atlantic region, and between this region and other parts of North America. The addition of a proposed new MDN site in Maryland will help improve network resolution in the region. Beginning this fall, we will utilize the alternate sampling orifice in the MDN collector to collect a weekly trace element sample at VA-08. With the addition of trace element sampling, we hope to gradually expand the interpretive capability of VA-08.

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Toward Understanding the Shifting Balance of Sulfate and Nitrate in NADP Data

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The wet deposition of anthropogenic sulfur and nitrogen compounds depends critically on their ability to interact effectively with cloud particles and be carried to the ground with precipitation. The primary forms of these two classes of compounds, namely sulfur dioxide and the nitrogen oxides, are relatively insoluble in liquid water, so only the oxidized forms (sulfate and nitrate) are found in precipitation. Data acquired over many years by the NADP in the northeastern United States show consistent seasonal and annual trends. Over the course of a year, the molar ratio of sulfate to nitrate in precipitation is found to vary by a factor of about two, the summer season being dominated by sulfate deposition, while winter precipitation tends to be richer in nitrate. This seasonal pattern can be interpreted in terms of known oxidation mechanisms based on free-radical chemistry, but the long-term trend requires understanding of both the atmospheric chemistry and the changes in primary emissions. As the emissions of sulfur dioxide come down, the sulfate-to-nitrate ratio is shifting in favor of nitrate deposition, with the fastest changes occurring in the warm summer season.

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We Know Snow: All Weather Precipitation Accumulation Gauge (AWPAG)

Malcolm C. Lynch
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In October 2001, the National Weather Service selected C.C. Lynch & Associates, Inc. to develop the Ott Pluvio as the new AWPAG “to more accurately measure frozen precipitation” at more than 300 major airports nationwide.

The Ott Pluviois a state-of-the-art precipitation gauge, highly accurate and robust with many advantages over typical commercial rain gauges.

The weight of precipitation gathered in the collecting container is measured by a precise weighing cell that has proven long-term stability in excess of 5 years.This will allow for easy QA/QC calibration checks, versus annual calibration requirements and less suspect or erroneous data.

The Pluvio offers high resolution (0.001 inch) and exacting accuracy (<0.0016 inch), excelling in extreme environments where conventional gauges either under report, false report, or miss events altogether.

The Pluvio is so precise it is capable of measuring extremely fine precipitation (mist, drizzle and light snow) long before other weighing technologies can identify it. This precision allows for early identification of the start of precipitation.

Both environmental and destructive tests prove no problem to the Ott Pluvio AWPAG. The algorithm and sensor technology have been proven in windspeed testing from 40 to 125 mph with simulated wind pumping from 80 to 125 mph without false report, damage, or failure.

In blowing rain test the Pluvio AWPAG was subjected to blowing rain with windspeeds of 84 and 35 mph without false reports or failure. Accuracy of the measurements when compared to a precision lab scale were within 0.01 inch.

The Ott Pluvio AWPAG was subjected to freezing rain with wind testing to prove its ability to withstand large ice loading and to ensure that the orifice could remain free of ice build-up.

The smart ring heat and unique container design eliminate concerns with chimney effects and large surface areas or chimneys common to other precipitation sensors.

Telephone: 800-333-2252; website: www.ccla.com

An Approach to Atmospheric Deposition Data Management and Data Products

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The Visibility Information Exchange Web System (VIEWS) is an online repository of visibility data, research products, and ideas designed to support the Regional Haze Rule enacted by the U.S. Environmental Protection Agency (EPA) to reduce regional haze in national parks and wilderness areas. In addition to this primary goal, VIEWS supports global efforts to better understand the effects of air pollution on visibility and to improve air quality in general. With the recent addition of data from the NADP/AIRMoN and NADP/NTN networks, interesting comparisons between wet deposition data and aerosol data are now more easily done using the tools and data products on the VIEWS website. By aggregating deposition and aerosol data to common time intervals for similar species, comparisons of short and long terms trends, visualization of spatial distribution with isopleth maps, and analyses of data from collocated sites are now available for a wide variety of monitoring networks. In addition, new insights into the import, transformation, and management of air quality data in general have been gained by the addition of NADP data to the VIEWS database system. By addressing data management challenges and developing tools for integrating data from often dissimilar networks, VIEWS aims to provide researchers, regulators, and the public with a more accurate and available perspective on relevant and comparable air quality data.

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Case Study of a Trans-Boundary Air Pollution Event in Nova Scotia, June 9, 2004

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Continental air masses that travel over heavily populated and industrialized regions of Eastern Canada and the North-eastern United States carry with them various air pollutants such as ground-level ozone (GLO) and its precursors, and fine particulate matter ($PM_{2.5}$). Nova Scotia Environment and Labour (NSEL) and the Meteorological Service of Canada (MSC) combined have a network consisting of five continuous $PM_{2.5}$ monitors and seven GLO monitors in Nova Scotia. On June 9, 2004, the network of air-monitoring instruments recorded an episode of degraded air quality that encompassed the entire province. By utilizing MSC's back-trajectory model, $PM_{2.5}$ and GLO data, and meteorological data, we will show that the source of this event was dual causing two consecutive peaks in pollutant concentration. Firstly, an air mass that had stagnated over New England was reacted by solar radiation and then transported over Nova Scotia. Another air mass was transported at a higher altitude along the Saint Lawrence River corridor and mixed at lower altitude over Nova Scotia. By examining this event and comparing with past events we have gained a greater understanding of transport of air pollutants into Nova Scotia.

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Seasonal Patterns and Total Deposition of Mercury at Acadia National Park, Maine: Relationships to MDN Monitoring Data

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Chemical mass balances for nutrients and contaminants in watersheds in temperate, forested landscapes are often incomplete because dry deposition is not taken into account, and estimates of winter inputs are inadequate. While much is known about spatial and temporal patterns of wet deposition, estimates of dry and fog deposition are uncommon or highly uncertain, and these forms of deposition can comprise half or more of total deposition. Here we (1) compared seasonal patterns of wet deposition of total mercury (Hg) at Acadia National Park to two other NADP/MDN sites for 2000, 2001, and 2002, and (2) examined the relationships between wet deposition and throughfall fluxes of Hg during the 2000 growing season at Acadia. An assessment published in the 1990s indicated that winter deposition of Hg was low in the Midwest and Mid- to South-Atlantic coast compared to other seasons, and attributed this low winter deposition to differences in scavenging of Hg by snow, and inhibition of in-cloud oxidation to Hg^0 by colder temperatures. We repeated the 1990s assessment, adding the coastal Maine Acadia site. In this analysis, winter deposition of Hg was two- to five- times higher for the Acadia site than for a site in Wisconsin, and equaled or exceeded winter deposition at a site in South Carolina. Higher winter wet deposition at Acadia as compared to South Carolina may be a result of greater snow- and wet-fall amounts during this season; Acadia received an average of 195 cm of snow per year for the period analyzed, while the South Carolina site received 3 cm. The Wisconsin site received more snowfall than Acadia – 328 cm during the period investigated – but deposition of Hg in summer was much higher than in winter. Throughfall, water that falls to the forest floor during a precipitation event, has been used as a surrogate for total deposition. Its chemistry is influenced by direct atmospheric deposition as well as by canopy exchange processes. Measurement of conservative (i.e., biologically inactive) substances, such as sulfur, in throughfall has been used successfully in many ecosystems as a direct tracer of atmospheric deposition. The relationship of a nonconservative ion to sulfur can be used to elucidate pattern and process of thenonconservative ion as well.Mercury in throughfall was correlated with sulfur in throuhgfall. In May-November 2000, throughfall deposition of mercury was 1.6-2.6 times higher at forested than open or MDN sites at Acadia. In a network of 52 sites distributed throughout two small watersheds at Acadia, throughfall deposition at coniferous sites was 40.2 (±1.2) ng/m^2/day, and at deciduous sites was 31.9 (±1.6) ng/m^2/day. Our data suggest that the dry deposition of hg is likely to be at least equivalent to wet deposition and that coniferous vegetation receives greater deposition of mercury than do deciduous canopies.

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Development of a Gradient Analyzer for Aerosols and Gases

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Recently we have developed an instrument to determine concentrations of atmospheric inorganic gases and aerosol species with sufficient precision for flux measurements. The instrument, called GRAEGOR, reaches a precision of 1% at ambient mixing ratio’s and has a detection limit of 1 to 10 ppt.

Graegor measures HCl, HNO_3, HNO_2, SO_2 and NH_3 in gas phase as well as Cl^-, NO_3^-, SO_4^{2-} and NH_4^+ in the particle phase as a 30-minute sample per hour. In two different sampling boxes, with local intelligence, the gases are continuously collected in a Wet Rotating Denuder (WRD) and particles are continuously collected in a Steam Jet Aerosol Collector (SJAC). The four sample solutions are pumped into a detection box by syringe pumps, which operate as discrete sample collectors. An anion chromatograph and a membrane diffusion detector for ammonium perform the sequential analysis.
A preliminary data set is presented of measurements at the ECN-site near the Dutch coast at one height revealing insight of the precision.

GRAEGOR is a state of the art instrument based on techniques used in other instruments developed by ECN like the ammonia monitors AMANDA, AMOR and AiRRmonia, the flux version GRAHAM. And also the batch-wise, on-line, gradient and size-resolving versions of the WRD-SJAC sampler combined with an anion chromatograph for the other inorganic species.
The development of GRAEGOR is sponsored by the Dutch Ministry of Environmental Affairs and CEH (Centre for Ecology and Hydrology) Edinburgh, which will also be the first group to operate the instrument.

Reference:
J. Slanina, H.M. ten Brink, R.P. Otjes, A, Even, P. Jongejan, A. Khlystov, A. Waijers-IJpelaan, M. Hu, Y. Lu, 2001. The continuous analysis of nitrate and ammonium in aerosols by the steam jet aerosol collector (SJAC): extension and validation of the methodology. Atmospheric Environment 35, 2319-2330

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Wet Deposition of Mercury in the U.S. and Canada, 1996-2002: Results from the NADP Mercury Deposition Network (MDN)

Eric Prestbo[1], Robert Brunette[1], David Gay[2], and Bob Larson[2],

The Mercury Deposition Network (MDN) is part of the National Atmospheric Deposition Program (NADP). MDN operates sites in the United States and Canada to monitor total mercury in wet deposition. Annual summaries from weekly data collected at 70 locations are reported for the years 1996-2002. The median mercury concentration for almost 10,000 samples collected during this period is 9.7 ng/L. Volume-weighted total mercury concentrations are lowest at remote sites in northern California and the Canadian maritime provinces (4 to 6 ng/L) and highest in Florida and Minnesota (10 to 16 ng/L). Wet deposition of mercury depends on both the concentration in the rain and the total rainfall amount. Wet deposition of mercury ranges from over 25 $\mu g/m^2/yr$ in south Florida to less than 3 $\mu g/m^2/yr$ in northern California. Mercury deposition is strongly seasonal in eastern North America. In the summer, the average mercury concentration in rain is about double that found in the winter. The average wet deposition of mercury is more than 3 times higher in summer than in winter. No statistically significant time trends have been measured. In addition, several MDN sites have been measuring monomethyl mercury wet-deposition. Monomethyl mercury concentrations, seasonal trends and comparison to total mercury deposition will be highlighted

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Ten Years of Quality Assurance at the CAL

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Quality Assurance (QA)Reports for the CAL have been published annually or semi-annually throughout the duration of NADP. QA samples are analyzed daily, weekly, and monthly at the CAL, monitoring the cleanliness of the equipment and supplies used for NADP and the condition and quality of the analyses. Over the years, although the actual solutions have often changed, the overall quality of the CAL has remained consistent. In addition, the CAL has participated in laboratory intercomparisons. This poster looks at supply cleanliness for the last ten years as well as the status of the CAL in an international laboratory intercomparison program.

Modeling Mercury Deposition in Maryland Using CALPUFF

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This poster presents an overview of atmospheric mercury deposition modeling undertaken by the Maryland Power Plant Research Program (PPRP) to evaluate the impacts of regional sources on deposition of mercury in the State of Maryland. Emphasis is placed on estimating dry and wet deposition impacts (flux and load), evaluating the relative contributions from electrical generating units (EGU) and non-EGU sources, and evaluating the potential for localized deposition impacts associated with sources within the state.

The study utilizes the CALPUFF/CALMET modeling system; this multilayer Lagrangian puff model employs a combination of three-dimensional meteorological data and landuse characteristics to estimate transport, dispersion, and wet and dry deposition on a regional scale. This application of CALPUFF incorporates mercury emissions from point sources within the Chesapeake Bay airshed, extending from New York to South Carolina and from Indiana to the Atlantic Ocean, with emissions and stack characteristics derived from EPA's National Emissions Inventory (NEI) for 1999. Simplifying assumptions regarding mercury speciation and chemical transformation are made to account for the differing transport and deposition characteristics of elemental, reactive divalent, and particulate mercury. Modeling has been performed using a range of coefficients and emissions speciation for each form of airborne mercury, to evaluate the effect of uncertainty in these parameters on both loading and flux within the modeling domain. The mercury transformation scheme within EPA's REMSAD model was evaluated and provided insights into the simplified parameterizations utilized with CALPUFF.

Data collected at NADP's Mercury Deposition Network (MDN) sites throughout the domain were used to compare CALPUFF predictions to measured wet deposition; in general, model predictions are consistent with measurements, but large differences exist for some sites. Hypotheses are put forward to explain some of the large differences; uncertainties in the emissions inventory in some cases can overshadow differences in the treatment of transformation chemistry and deposition parameterization. When both loading (i.e., total mass deposited over a wide area) and flux (i.e., deposition per unit area) are taken into account, the existence of some degree of localized impacts is shown to be robust across a wide range of assumptions regarding mercury transport, transformation, and deposition.

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A Source Apportionment of Nitrogen Deposition in the Maryland Coastal Bays

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This poster describes a source apportionment analysis of nitrogen deposition in the Maryland Coastal Bays, based on the CALPUFF modeling system. Nutrient concentrations on the Delmarva Peninsula are among the highest in the nation and estimates of nutrient N from atmospheric sources may comprise about 55% of the total, about 318,403 Kg-N/yr.

Many of the current estimates of atmospherically derived nitrogen are obtained from observations of wet and dry deposition. National programs, especially the National Atmospheric Deposition Program [NADP] for wet deposition, the Clean Air Status and Trends Network [CASTNET] for dry deposition and the Atmospheric Integrated Research Monitoring Network [AIRMoN] for both wet and dry deposition have provided the bulk of the data for these types of analyses. While these programs provide estimates of inputs they do not allow individual source contributions to be understood in more than a very broad way. For nutrient management purposes, a modeling framework that covers the full spatial scale of emissions and deposition and which derives estimates in a way that includes these atmospheric emission sources explicitly is desirable if credits for actions by individuals, either voluntary or through some nutrient trading program are to be assessed.

The Lagrangian formulation used in CALPUFF allows sources to be modeled individually and their combined impacts assessed. Estimates of ammonium deposition are included by using sulfate as a surrogate. Organic N is not included. Sources are divided in four main categories: electricity generating units [EGU], mobile sources, industrial sources and area sources. The results of this analysis show EGUs to be the largest contributing sources category, while mobile and area sources in Sussex County, Delaware are the largest individual sources. This type of information is useful for the development of mitigation strategies, especially voluntary efforts, by estimating “credits” for emission reduction activities at specific sources.

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Temporal Variation in Daily Concentrations of Ozone and Acid Related Substances at Saturna Island, British Columbia, Canada

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A multiple linear regression model was used to investigate seasonal and long-term trends in concentrations of ozone and acid related substances at the Saturna Island monitoring station in southwestern British Columbia from 1991 to 2000. The Saturna Island station is part of the Canadian Air and Precipitation Monitoring Network (CAPMoN), established and operated across Canada by the federal government. The station is not influenced by local sources of pollution, however both industrial and urban pollution from sources 30-50 km away are expected to affect local air quality. Results of General Least Squares analysis indicated the presence of several temporal cycles ranging from six months to four years. Statistically significant primary cycles with a period of one year were found for O_3, SO_2 , HNO_3 and aerosol concentrations of SO_4^{2-}, Ca^{2+} and Cl^- . Of these, peak median concentrations occurred during the spring for O_3 and Ca^{2+}, during the warmer, drier months (April-September) for SO_4^{2-} and HNO_3, and during the cooler, wetter months (October-March) for SO_2, and Cl^-. Statistically significant secondary cycles of six months duration were seen for O_3, SO_4^{2-}, HNO_3, Ca^{2+} and Cl^-. Primary cycles with a period of six months were found for NO_3^-, K^+ and Mg^{2+}. Daily maximum O_3 concentrations exhibited a statistically significant increase over the period of record of 0.33 ±0.26 ppb/yr. Statistically significant declines were found for SO_2, SO_4^{2-}, HNO_3, Ca^{2+} and K^+, ranging from 20-36% from concentrations at the start of the sampling period. Declines in ambient concentrations of SO_2, SO_4^{2-} and HNO_3 are believed to reflect local declines in anthropogenic emissions of the primary precursors SO_2 and NOx over the past decade. Similar declines have been reported throughout North America in response to tightening regulations of these emissions. Trends in Ca^{2+} and K^+ ions are in line with a broader North American declining trend in acid neutralizing cations.

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Dry Deposition of NH_3 in the Vicinity of a Swine Production Facility

John Walker*[1], Wayne Robarge[2], Yihua Wu[3]

Globally, domestic animals are the largest source (22 Tg N yr $^{-1}$, 1 Tg = 10^{12} g) of atmospheric NH_3, comprising approximately 40% of natural and anthropogenic emissions combined, while synthetic fertilizers and agricultural crops together contribute an additional 12.6 Tg NH_3-N y $^{-1}$ (23% of total emissions).Within and downwind of mixed (animal and crop production) agricultural regions, NH_3 therefore plays a significant role in the formation of inorganic ambient aerosol and deposition of nitrogen to terrestrial and aquatic systems. While animal production facilities have been identified as important sources of NH_3, there are no estimates of local NH_3 dry deposition for U.S. systems. This project investigates the dry deposition of NH_3 near a 5000 head swine production facility located in eastern North Carolina. Passive samplers are used to measure weekly-integrated NH_3 concentrations at 22 sites along horizontal gradients from the lagoon/housing complex out to a distance of 500 m. Dry deposition is estimated using measured concentrations in combination with a resistance model that includes cuticular and stomatal uptake as well as the vegetation compensation point for NH_3. Data are presented for the period 5/1/03 to 5/1/04. Using a steady-state emission factor of 7.0 kg NH_3 animal $^{-1}$ yr $^{-1}$, average dry NH_3 deposition within 500 m of the housing/lagoon complex accounts for approximately 13% of emissions. The majority of NH_3 emitted is therefore available for $PM_{2.5}$ formation and deposition to downwind ecosystems. Though limited in spatial extent, high deposition rates near the source are likely to exceed the critical nitrogen loads for most ecosystems, suggesting that siting requirements for animal production facilities should consider local nitrogen deposition as a potential environmental burden.

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Recent Programmatic Changes to the U.S. Geological Survey External Quality Assurance Project for the NADP

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The U.S. Geological Survey External Quality Assurance (QA) Project for the National Atmospheric Deposition Program (NADP) is comprised of several programs designed to evaluate and document sample collection and analytical procedures used by the NADP. Since 1978, the scope of the programs has changed to meet specific needs of the NADP and its data users.

Changes to the USGS external QA programs during 2003-2005 are as follows.

1. During 2003-04, laboratory and field QA programs were initiated for the Mercury Deposition Network (MDN). An interlaboratory-comparison program was initiated to test for accuracy and bias at mercury analytical laboratories The system audit program was established to test for mercury contamination and loss from field exposure, handling, and shipping of MDN samples.
2. In 2003, the sample handling evaluation (SHE) program was initiated to measure the effects of sample handling and shipping on NADP/NTN sample chemistry. The SHE program was discontinued in mid-2004 after evaluation of the data revealed that the program provided little additional information to that provided by the existing field audit program. Consequently, the field audit program, which evaluated up to 100 NTN sites annually, will be expanded in 2005 to include all NADP/NTN sites.
3. By committee consensus, NADP/NTN field measurements of pH and specific conductance will be discontinued starting in 2005. Therefore, the USGS intersite program, which evaluated site operator performance for field chemistry measurements, will be discontinued in 2004.
4. The collocated sampler program, initiated in 1988, has been used to measure overall error inherent in NADP/NTN measurements. Each year, the collocated-sampler sites were moved to NADP/NTN sites in different ecoregions. In 2005, long-term collocated sites will be established at WI98, VT99, and one additional site. The long-term collocated sites will be used to quantify step-functions in the NTN data that might arise when NADP/NTN monitoring equipment is upgraded. The collocated existing and upgraded equipment will be operated at each site for three years after the NADP selects upgraded instrumentation for the NTN.

The USGS external QA programs will continue to evolve as the NTN and MDN instrumentation and protocols change. The QA data are interpreted and presented in USGS reports available on the World Wide Web or from the U.S. Government Printing Office and in scientific journals.

A Case Study of Ammonia Gas Exchanges in a Soybean Field of North Carolina with a New Resistance Model

Yihua Wu*, John Walker[2], Christa Peters-Lidard[1], Wayne Robarge[3]

A field experiment was conducted in a soybean field, Duplin County, North Carolina in the summer of 2002. Data from June 24th (DOY 185) and July 3rd (DOY 194) were selected for this study based on ammonia flux direction. There was a net deposition of ammonia on DOY 185, while there was a net emission on DOY 194. The major factor which caused the ammonia flux difference on these two days is atmospheric ammonia concentration, which is, on average, much higher on DOY 185 (20.38 $\mu g\ m^{-3}$) than on DOY 194 (6.62 $\mu g\ m^{-3}$). We hypothesize that higher atmospheric ammonia concentrations are related to the advection of emissions from hog farms located to the SSW of the site. For example, on DOY185 (net deposition) the wind direction was SSW (214.58 degree), while on DOY194 (net emission), the wind direction was EEN (84.77 degree). Differences in weather conditions on these two days also contribute to the differences in flux direction. To further study these effects, a new resistance model was developed to simulate ammonia flux in this case. The new model is based on the Multi-Layer BioChemical deposition (MLBC) model (Wu et al, 2003) with the addition of a leaf ammonia compensation point parameterization. The MLBC model considers some biochemical processes, such as photosynthesis, respiration, and membrane passive transport of cuticle. The model was run for these two days with a time interval of 30 minutes, and preliminary results suggest that the MLBC model can represent the combined effects of advection and changing weather conditions on ammonia fluxes observed at this site.

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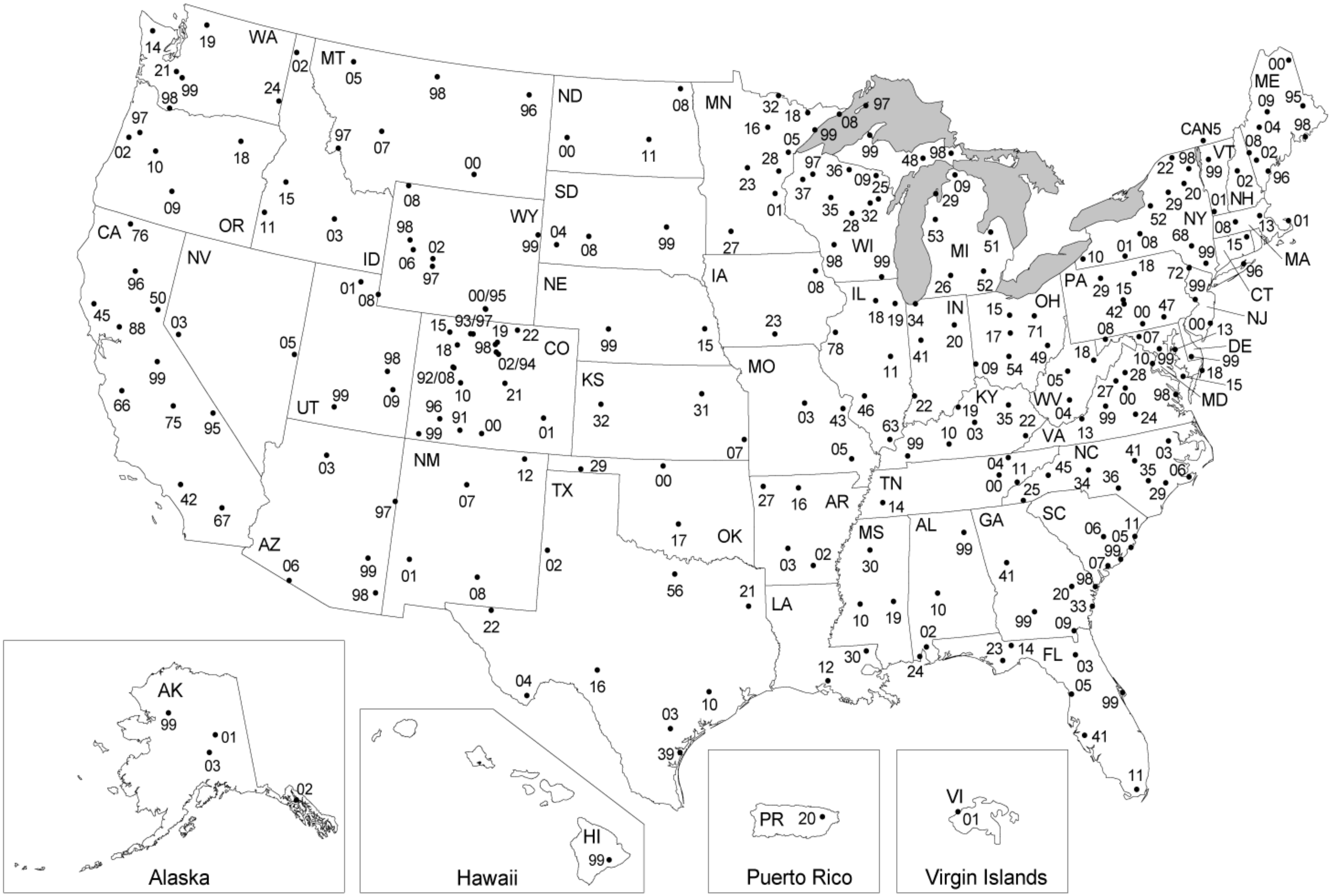
NTN MAP AND SITE LISTINGS

National Atmospheric Deposition Program
National Trends Network



National Atmospheric Deposition Program/National Trends Network Sites
August 31, 2004

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL02	Delta Elementary	MDN	Mobile Bay Nat Est. Prog/Dauphin Is.Sea Lab	06/01
AL10	Black Belt Agricultural Experiment Substation		US Geological Survey	08/83
AL24	Bay Road	MDN	Mobile Bay National Estuary Program	05/01
AL99	Sand Mountain Agricultural Experiment Substation		Tennessee Valley Authority	10/84
Alaska				
AK01	Poker Creek		USDA Forest Service	12/92
AK02	Juneau		USDA Forest Service/Univ. of Alaska SE	06/04
AK03	Denali NP - Mount McKinley		National Park Service - Air Resources Div	06/80
AK99	Ambler	MDN	National Park Service - Air Resources Div	05/04
Arizona				
AZ03	Grand Canyon NP - Hopi Point		National Park Service - Air Resources Div	08/81
AZ06	Organ Pipe Cactus NM		National Park Service - Air Resources Div	04/80
AZ97	Petrified Forest National Park-Rainbow Forest		National Park Service - Air Resources Div	12/02
AZ98	Chiricahua		US Environmental Protection Agency-CAMD	02/99
AZ99	Oliver Knoll		US Geological Survey	08/81
Arkansas				
AR02	Warren 2WSW		US Geological Survey	05/82
AR03	Caddo Valley		US Geological Survey	12/83
AR16	Buffalo NR - Buffalo Point		National Park Service - Air Resources Div	07/82
AR27	Fayetteville		US Geological Survey	04/80
California				
CA42	Tanbark Flat		USDA Forest Service	01/82
CA45	Hopland		US Geological Survey	10/79
CA50	Sagehen Creek		US Geological Survey	11/01
CA66	Pinnacles NM - Bear Valley		National Park Service - Air Resources Div	11/99
CA67	Joshua Tree NP - Black Rock		National Park Service - Air Resources Div	09/00
CA75	Sequoia NP - Giant Forest	MDN	National Park Service - Air Resources Div	07/80
CA76	Montague		US Geological Survey	06/85
CA88	Davis		US Geological Survey	09/78
CA95	Death Valley NP - Cow Creek		National Park Service - Air Resources Div	02/00
CA96	Lassen Volcanic NP - Manzanita Lake		National Park Service - Air Resources Div	06/00
CA99	Yosemite NP - Hodgdon Meadow		National Park Service - Air Resources Div	12/81
Colorado				
CO00	Alamosa		US Geological Survey	04/80
CO01	Las Animas Fish Hatchery		US Geological Survey	10/83
CO02	Niwot Saddle		NSF-INSTAAR/University of Colorado	06/84
CO08	Four Mile Park		US Environmental Protection Agency-CAMD	12/87
CO10	Gothic		US Environmental Protection Agency-CAMD	02/99
CO15	Sand Spring		Bureau of Land Management	03/79
CO18	Ripple Creek Pass		Air Science, Incorporated	05/03
CO19	Rocky Mountain NP - Beaver Meadows		National Park Service - Air Resources Div	05/80
CO21	Manitou		USDA Forest Service	10/78
CO22	Pawnee		NSF-LTER/Colorado State University	05/79
CO91	Wolf Creek Pass		USDA Forest Service	05/92
CO92	Sunlight Peak		US Environmental Protection Agency-CAMD	01/88
CO93	Buffalo Pass - Dry Lake		USDA Forest Service	10/86
CO94	Sugarloaf		US Environmental Protection Agency-CAMD	11/86
CO96	Molas Pass		USDA Forest Service	07/86
CO97	Buffalo Pass - Summit Lake	MDN	USDA Forest Service	02/84
CO98	Rocky Mountain NP - Loch Vale		USGS/Colorado State University	08/83
CO99	Mesa Verde NP - Chapin Mesa	MDN	US Geological Survey	04/81
Connecticut				
CT15	Abington		US Environmental Protection Agency-CAMD	01/99
Delaware				
DE99	Trap Pond State Park		US EPA-CAMD/Cheapeake Bay Program	05/03
Florida				
FL03	Bradford Forest		St. John's River Water Management District	10/78
FL05	Chassahowitzka NWR	MDN	US Fish & Wildlife Serv - Air Quality Branch	08/96
FL11	Everglades NP - Research Center	MDN	National Park Service - Air Resources Div	06/80
FL14	Quincy		US Geological Survey	03/84
FL23	Sumatra		US Environmental Protection Agency-CAMD	01/99

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
FL41	Verna Well Field		US Geological Survey	08/83
FL99	Kennedy Space Center		NASA/Dynamac Corporation	08/83
Georgia				
GA09	Okefenokee NWR	MDN	US Fish & Wildlife Serv - Air Quality Branch	06/97
GA20	Bellville		US Environmental Protection Agency-CAMD	04/83
GA33	Sapelo Island		Georgia Department of Natural Resources	11/02
GA41	Georgia Station		SAES-University of Georgia	10/78
GA98	Skidaway		NSF/Skidaway Institute of Oceanography	06/02
GA99	Chula		US Geological Survey	02/94
Hawaii				
HI99	Hawaii Volcanoes NP - Thurston		National Park Service - Air Resources Div	11/00
Idaho				
ID02	Priest River Experimental Forest		USDA Forest Service-Rocky Mountain Res. Stn.	12/02
ID03	Craters of the Moon NM		National Park Service - Air Resources Div	08/80
ID11	Reynolds Creek		US Geological Survey	11/83
ID15	Smiths Ferry		US Geological Survey	10/84
Illinois				
IL11	Bondville	AIRMoN/MDN	SAES-University of Illinois	02/79
IL18	Shabbona		SAES-University of Illinois	05/81
IL19	Argonne		DOE-Argonne National Laboratory	03/80
IL46	Alhambra		US Environmental Protection Agency-CAMD	01/99
IL63	Dixon Springs Agricultural Center		SAES-University of Illinois	01/79
IL78	Monmouth		US Geological Survey	01/85
Indiana				
IN20	Roush Lake	MDN	US Geological Survey	08/83
IN22	Southwest-Purdue Agricultural Center		US Geological Survey	09/84
IN34	Indiana Dunes NL	MDN	National Park Service - Air Resources Div	07/80
IN41	Agronomy Center for Research and Extension		SAES-Purdue University	07/82
Iowa				
IA08	Big Springs Fish Hatchery		US Geological Survey	08/84
IA23	McNay Memorial Research Center		US Geological Survey	09/84
Kansas				
KS07	Farlington Fish Hatchery		US Geological Survey	03/84
KS31	Konza Prairie		SAES-Kansas State University	08/82
KS32	Lake Scott State Park		US Geological Survey	03/84
Kentucky				
KY03	Mackville		US Geological Survey	11/83
KY10	Mammoth Cave NP-Houchin Meadow	MDN	National Park Service - Air Resources Div	08/02
KY19	Seneca Park		US Geological Survey	10/03
KY22	Lilley Cornett Woods		NOAA-Air Resources Lab	09/83
KY35	Clark State Fish Hatchery		US Geological Survey	08/83
KY99	Mulberry Flats		TVA/Murray State University	12/94
Louisiana				
LA12	Iberia Research Station		US Geological Survey	11/82
LA30	Southeast Research Station		US Geological Survey	01/83
Maine				
ME00	Caribou		NOAA-Air Resources Lab	04/80
ME02	Bridgton	MDN	EPA/Maine Dept of Environmental Protection	09/80
ME04	Carrabassett Valley		US Environmental Protection Agency-CAMD	03/02
ME08	Gilead		US Geological Survey	09/99
ME09	Greenville Station	MDN	SAES-University of Maine	11/79
ME95	Wolapomomqot Ciw Wocuk		EPA/Passamaquoddy Tribe	06/02
ME96	Casco Bay - Wolfe's Neck Farm	MDN	EPA/Maine Dept of Environmental Protection	01/98
ME98	Acadia NP - McFarland Hill	MDN	National Park Service - Air Resources Div	11/81
Maryland				
MD07	Catoctin Mountain Park		National Park Service - Air Resources Div	05/03
MD08	Piney Reservoir	MDN	MD-DNR/Univ. of Maryland-Appalachian Lab	06/04
MD13	Wye		SAES-University of Maryland	03/83
MD15	Smith Island		NOAA-Air Resources Lab	06/04
MD18	Assateague Island NS - Woodcock		Maryland Department of Natural Resources	09/00
MD99	Beltsville	MDN	MD-DNR/Univ. of Maryland-Chesapeake Bio Lab	06/04
Massachusetts				
MA01	North Atlantic Coastal Lab	MDN	National Park Service - Air Resources Div	12/81
MA08	Quabbin Reservoir		N.E. States for Coor. Air Use Management	03/82
MA13	East		N.E. States for Coor. Air Use Management	02/82

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Michigan				
MI09	Douglas Lake - University Michigan Biological Station		USDA/Michigan State University	07/79
MI26	Kellogg Biological Station		USDA/Michigan State University	06/79
MI29	Peshawbestown		US Environmental Protection Agency-CAMD	01/02
MI48	Seney NWR - Headquarters	MDN	US Fish & Wildlife Serv - Air Quality Branch	11/00
MI51	Unionville		US Environmental Protection Agency-CAMD	01/99
MI52	Ann Arbor		US Environmental Protection Agency-CAMD	01/99
MI53	Wellston		USDA Forest Service	10/78
MI97	Isle Royale NP - Wallace Lake		National Park Service - Air Resources Div	05/85
MI98	Raco		US Environmental Protection Agency-CAMD	05/84
MI99	Chassell		National Park Service - Air Resources Div	02/83
Minnesota				
MN01	Cedar Creek		Minnesota Pollution Control Agency	12/96
MN05	Fond du Lac		EPA/Fond du Lac Reservation	11/96
MN08	Hovland		Minnesota Pollution Control Agency	12/96
MN16	Marcell Experimental Forest	MDN	USDA Forest Service	07/78
MN18	Fernberg	MDN	US Environmental Protection Agency-CAMD	11/80
MN23	Camp Ripley	MDN	US Geological Survey	10/83
MN27	Lamberton	MDN	Minnesota Pollution Control Agency	01/79
MN28	Grindstone Lake		Minnesota Pollution Control Agency	12/96
MN32	Voyageurs NP - Sullivan Bay		National Park Service - Air Resources Div	05/00
MN99	Wolf Ridge		Minnesota Pollution Control Agency	12/96
Mississippi				
MS10	Clinton		US Geological Survey	07/84
MS19	Newton		NOAA-Air Resources Lab	11/86
MS30	Coffeeville	`	Tennessee Valley Authority	07/84
Missouri				
MO03	Ashland Wildlife Area		US Geological Survey	10/81
MO05	University Forest		US Geological Survey	10/81
MO43	Tyson Research Center		Washington University	08/01
Montana				
MT00	Little Bighorn Battlefield NM		US Geological Survey	07/84
MT05	Glacier NP - Fire Weather Station		National Park Service - Air Resources Div	06/80
MT07	Clancy		US Geological Survey	01/84
MT96	Poplar River		EPA/Ft. Peck Tribes	12/99
MT97	Lost Trail Pass		USDA Forest Service	09/90
MT98	Havre - Northern Agricultural Research Center		US Geological Survey	07/85
Nebraska				
NE15	Mead		SAES-University of Nebraska	07/78
NE99	North Platte Agricultural Experiment Station		US Geological Survey	09/85
Nevada				
NV03	Smith Valley		US Geological Survey	08/85
NV05	Great Basin NP - Lehman Caves		National Park Service - Air Resources Div	01/85
New Hampshire				
NH02	Hubbard Brook		USDA Forest Service	07/78
New Jersey				
NJ00	Edwin B. Forsythe NWR		US Fish & Wildlife Serv - Air Quality Branch	10/98
NJ99	Washington Crossing		US Environmental Protection Agency-CAMD	08/81
New Mexico				
NM01	Gila Cliff Dwellings NM		EPA/New Mexico Environment Dept	07/85
*NM07	Bandelier NM		DOE-Los Alamos National Lab	06/82
NM08	Mayhill		US Geological Survey	01/84
NM12	Capulin Volcano NM		EPA/New Mexico Environment Dept	11/84
New York				
NY01	Alfred		US Geological Survey	06/04
NY08	Aurora Research Farm		USDA/Cornell University	04/79
NY10	Chautauqua		US Geological Survey	06/80
NY20	Huntington Wildlife	MDN	EPA/State Univ of New York-Syracuse	10/78
NY22	Akwesasne Mohawk - Fort Covington		US Environmental Protection Agency-CAMD	08/99
NY29	Moss Lake		U.S. Geological Survey	07/03
NY52	Bennett Bridge		EPA/State Univ of New York-Oswego	06/80
NY68	Biscuit Brook	MDN	US Geological Survey	10/83
NY96	Cedar Beach, Southold		EPA/Suffolk DHS-Peconic Estuary Program	11/03
NY98	Whiteface Mountain		US Geological Survey	07/84
NY99	West Point		US Geological Survey	09/83

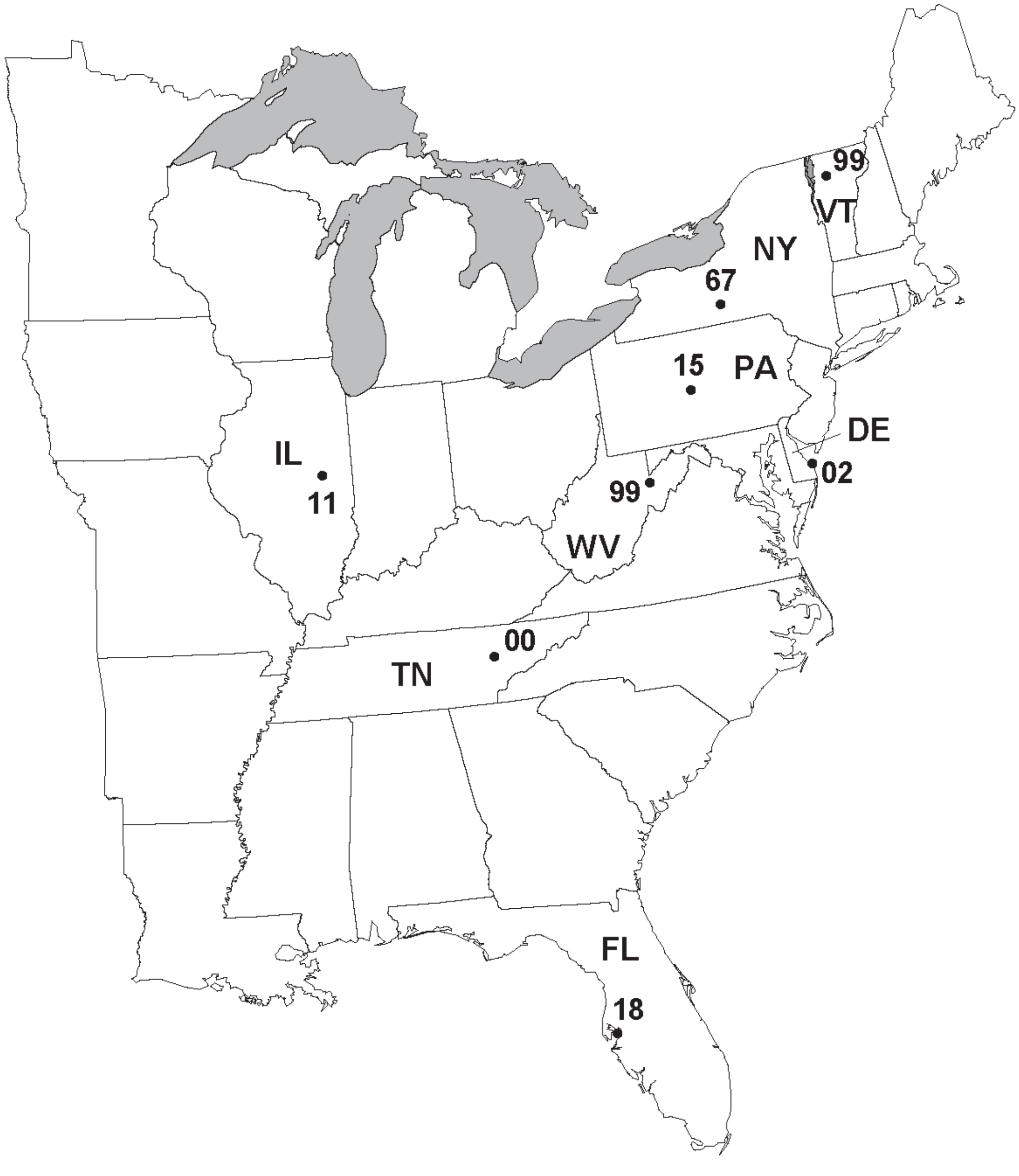
State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
North Carolina				
NC03	Lewiston		North Carolina State University	10/78
NC06	Beaufort		US Environmental Protection Agency-CAMD	01/99
NC25	Coweeta		USDA Forest Service	07/78
NC29	Hofmann Forest		North Carolina State University	07/02
NC34	Piedmont Research Station		North Carolina State University	10/78
NC35	Clinton Crops Research Station		North Carolina State University	10/78
NC36	Jordan Creek		US Geological Survey	10/83
NC41	Finley Farms		North Carolina State University	10/78
NC45	Mount Mitchell		North Carolina State University	11/85
North Dakota				
ND00	Theodore Roosevelt NP-Painted Canyon		National Park Service-Air Resources Div	01/01
ND08	Icelandic State Park		US Geological Survey	10/83
ND11	Woodworth		US Geological Survey	11/83
Ohio				
OH09	Oxford		US Geological Survey	08/84
OH15	Lykens		US Environmental Protection Agency-CAMD	01/99
OH17	Delaware		USDA Forest Service	10/78
OH49	Caldwell		US Geological Survey	09/78
OH54	Deer Creek State Park		US Environmental Protection Agency-CAMD	01/99
OH71	Wooster		US Geological Survey	09/78
Oklahoma				
OK00	Salt Plains NWR		US Geological Survey	12/83
OK17	Great Plains Apiaries		NOAA-Air Resources Lab	03/83
OK29	Goodwell Research Station		US Geological Survey	01/85
Oregon				
OR02	Alsea Guard Ranger Station		US Environmental Protection Agency-CAMD	12/79
OR09	Silver Lake Ranger Station		US Geological Survey	08/83
OR10	H J Andrews Experimental Forest	MDN	USDA Forest Service	05/80
OR18	Starkey Experimental Forest		US Geological Survey	03/84
OR97	Hyslop Farm		US Environmental Protection Agency-CAMD	04/83
Pennsylvania				
PA00	Arendtsville	MDN	US Environmental Protection Agency-CAMD	01/99
PA15	Penn State	AIRMoN	NOAA-Air Resources Lab	06/83
PA18	Young Woman's Creek		US Geological Survey	04/99
PA29	Kane Experimental Forest		USDA Forest Service	07/78
PA42	Leading Ridge		SAES-Pennsylvania State University	04/79
PA47	Millersville	MDN	PA Dept of Env Protection/Penn State Univ	11/02
PA72	Milford	MDN	USDA Forest Service	12/83
Puerto Rico				
PR20	El Verde		USDA Forest Service	02/85
South Carolina				
SC05	Cape Romain NWR		US Fish & Wildlife Serv - Air Quality Branch	11/00
SC06	Santee NWR		US Geological Survey	07/84
SC07	Ace Basin NERR		NOAA/SC Department of Natural Resources	12/01
SC11	North Inlet-Winyah Bay NERR		EPA/SC Dept of Health and Env Control	01/02
SC99	Fort Johnson		EPA/SC Dept of Health and Env Control	03/02
South Dakota				
SD04	Wind Cave National Park-Elk Mountain		National Park Service - Air Resources Div	11/02
SD08	Cottonwood		NOAA-Air Resources Lab	10/83
SD99	Huron Well Field		US Geological Survey	11/83
Tennessee				
TN00	Walker Branch Watershed	AIRMoN	DOE/Oak Ridge Natl Lab/Lockheed-Martin	03/80
TN04	Speedwell		US Environmental Protection Agency-CAMD	01/99
TN11	Great Smoky Mountain NP - Elkmont	MDN	National Park Service - Air Resources Div	08/80
TN14	Hatchie NWR		Tennessee Valley Authority	10/84
Texas				
TX02	Muleshoe NWR		US Geological Survey	06/85
TX03	Beeville		NOAA-Air Resources Lab	02/84
TX04	Big Bend NP - K-Bar		National Park Service - Air Resources Div	04/80
TX10	Attwater Prairie Chicken NWR		US Geological Survey	07/84
TX16	Sonora		US Geological Survey	06/84
TX21	Longview	MDN	Texas Commission on Environmental Quality	06/82

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
*TX22	Guadalupe Mountains NP-Frijole Ranger Stn		US Geological Survey	06/84
TX39	Texas A & M Corpus Christi		EPA/Texas A&M University	01/02
TX56	LBJ National Grasslands		US Geological Survey	09/83
Utah				
UT01	Logan		US Geological Survey	12/83
UT08	Murphy Ridge		BP Amoco	03/86
UT09	Canyonlands NP - Island in the Sky		National Park Service - Air Resources Div	11/97
UT98	Green River		US Geological Survey	04/85
UT99	Bryce Canyon NP - Repeater Hill		National Park Service - Air Resources Div	01/85
Vermont				
VT01	Bennington		US Geological Survey	04/81
VT99	Underhill	AIRMoN/MDN	US Geological Survey	06/84
Virgin Islands				
VI01	Virgin Islands NP - Lind Point		National Park Service - Air Resources Div	04/98
Virginia				
VA00	Charlottesville		US Geological Survey	10/84
VA10	Mason Neck Wildlife Refuge		VA Department of Environmental Quality	08/03
VA13	Horton's Station		Tennessee Valley Authority	07/78
VA24	Prince Edward		US Environmental Protection Agency-CAMD	01/99
VA27	James Madison University Farm		US Environmental Protection Agency-CAMD	07/02
VA28	Shenandoah NP - Big Meadows	MDN	National Park Service - Air Resources Div	05/81
VA98	Harcum		Virginia Department of Environmental Quality	08/04
VA99	Natural Bridge Station		Virginia Department of Environmental Quality	07/02
Washington				
WA14	Olympic NP - Hoh Ranger Station		National Park Service - Air Resources Div	05/80
WA19	North Cascades NP-Marblemount Ranger Stn		US Geological Survey	02/84
WA21	La Grande		US Environmental Protection Agency-CAMD	04/84
WA24	Palouse Conservation Farm		US Geological Survey	08/85
WA98	Columbia River Gorge		USDA Forest Service - Pacific Northwest Region	05/02
WA99	Mount Rainier NP - Tahoma Woods		National Park Service - Air Resources Div	10/99
West Virginia				
WV04	Babcock State Park		US Geological Survey	09/83
WV05	Cedar Creek State Park		US Environmental Protection Agency-CAMD	01/99
WV18	Parsons		USDA Forest Service	07/78
Wisconsin				
WI09	Popple River	MDN	Wisconsin Department of Natural Resources	12/86
WI25	Suring		Wisconsin Department of Natural Resources	01/85
WI28	Lake Dubay		Wisconsin Department of Natural Resources	06/82
WI32	Middle Village	MDN	EPA/Menominee Indian Tribe	01/02
WI35	Perkinstown		US Environmental Protection Agency-CAMD	01/99
WI36	Trout Lake	MDN	Wisconsin Department of Natural Resources	01/80
WI37	Spooner		Wisconsin Department of Natural Resources	06/80
WI97	Lac Courte Oreilles Reservation		EPA/Lac Courte Oreilles Conservation Dept	11/01
*WI98	Wildcat Mountain		Wisconsin Department of Natural Resources	08/89
WI99	Lake Geneva	MDN	Wisconsin Department of Natural Resources	06/84
Wyoming				
WY00	Snowy Range - West Glacier Lake		USDA Forest Service	04/86
WY02	Sinks Canyon		Bureau of Land Management	08/84
WY06	Pinedale		Bureau of Land Management	01/82
WY08	Yellowstone NP - Tower Falls		National Park Service - Air Resources Div.	06/80
WY95	Brooklyn Lake		USDA Forest Service	09/92
WY97	South Pass City		SF Phosphates Ltd/Bridger Teton NF	04/85
WY98	Gypsum Creek		Exxon Mobil Corporation/Bridget-Teton NF	12/84
WY99	Newcastle		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, 2004

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Delaware				
DE02	Lewes		NOAA-Air Resources Laboratory	09/92
Florida				
FL18	Tampa Bay		FL Department of Env. Protection	08/96
Illinois				
IL11	Bondville	MDN & NTN	NOAA-Air Resources Laboratory	10/92
New York				
NY67	Cornell University		NOAA-Air Resources Laboratory	09/92
Pennsylvania				
PA15	Penn State	NTN	NOAA-Air Resources Laboratory	10/92
Tennessee				
TN00	Oak Ridge National Lab	NTN	NOAA-Air Resources Laboratory	09/92
Vermont				
VT99	Underhill	NTN	NOAA-Air Resources Laboratory	01/93
West Virginia				
WV99	Canaan Valley Institute		NOAA-Air Resources Laboratory	06/00

MDN MAP AND SITE LISTINGS

National Atmospheric Deposition Program
Mercury Deposition Network

National Atmospheric Deposition Program/Mercury Deposition Network Sites
August 31, 2004

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL02	Delta Elementary	NTN	Mobile Bay Nat'l Estuary Prog-Dauphin Island Sea Lab	06/01
AL03	Centreville		Southern Company/Atmospheric Research and Analysis, Inc	06/00
AL24	Bay Road	NTN	Mobile Bay National Estuary Program-Dauphin Island Sea Lab	05/01
Alaska				
AK99	Ambler	NTN	National Park Service - Air Resources Division	05/04
California				
CA72	San Jose		San Francisco Estuary Institute	01/00
CA75	Sequoia NP-Giant Forest	NTN	National Park Service - Air Resources Division	07/03
Colorado				
CO97	Buffalo Pass - Summit Lake	NTN	USDA Forest Service-Rocky Mountain Research Station	09/98
CO99	Mesa Verde NP-Chapin Mesa	NTN	National Park Service - Air Resources Division	12/01
Florida				
FL04	Andytown		South Florida Water Management District	01/98
FL05	Chassahowitzka NWR	NTN	US Fish and Wildlife Service - Air Quality Branch	07/97
FL11	Everglades NP - Research Center	NTN	South Florida Water Management District	*12/95
FL32	Orlando		US Geological Survey	09/03
** FL34	ENRP		South Florida Water Management District	07/97
Georgia				
GA09	Okefenokee NWR	NTN	US Fish and Wildlife Service - Air Quality Branch	07/97
GA40	Yorkville		Southern Company/Atmospheric Research and Analysis, Inc	06/00
Illinois				
IL11	Bondville	AIRMoN/NTN	Illinois State Water Survey	*12/95
Indiana				
IN20	Roush Lake	NTN	Indiana Department of Environmental Management/USGS	10/00
IN21	Clifty Falls State Park		Indiana Department of Environmental Management/USGS	01/01
IN26	Fort Harrison State Park		Indiana Department of Environmental Management/USGS	04/03
IN28	Bloomington		Indiana Department of Environmental Management/USGS	12/00
IN34	Indiana Dunes NL	NTN	Indiana Department of Environmental Management/USGS	10/00
Kentucky				
KY10	Mammoth Cave NP-Houchin Meadow	NTN	National Park Service - Air Resources Division	08/02
Louisiana				
LA05	Lake Charles		Louisiana Department of Environmental Quality	10/98
LA10	Chase		Louisiana Department of Environmental Quality	10/98
LA23	Alexandria		Louisiana Department of Environmental Quality	02/01
LA28	Hammond		Louisiana Department of Environmental Quality	10/98
Maine				
ME02	Bridgton	NTN	EPA/Maine Department of Environmental Protection	06/97
ME09	Greenville Station	NTN	EPA/Maine Department of Environmental Protection	09/96
ME96	Casco Bay - Wolfe's Neck Farm	NTN	EPA/Maine Department of Environmental Protection	01/98
ME98	Acadia NP - McFarland Hill	NTN	NPS-Acadia NP & EPA/ME Dept of Environmental Protection	*01/96
Maryland				
MD08	Piney Reservior	NTN	MD-DNR/Univ of Maryland-Appalachian Lab	06/04
MD99	Beltsville	NTN	MD-DNR/Univ of Maryland-Chesapeake Bio Lab	06/04
Massachusetts				
MA01	North Atlantic Coastal Lab	NTN	NPS-Cape Cod National Seashore	07/03
Michigan				
MI48	Seney NWR - Headquarters	NTN	US Fish and Wildlife Service - Air Quality Branch	11/03
Minnesota				
MN16	Marcell Experimental Forest	NTN	USDA Forest Service-North Central Res Station & MNPCA	*12/95
MN18	Fernberg	NTN	USDA-FS - Superior NF & MN Pollution Control Agency	*01/96
MN22	Mille Lacs Band of Ojibwe		EPA/Mille Lacs Band of Ojibwe	04/02
MN23	Camp Ripley	NTN	Minnesota Pollution Control Agency	07/96
MN27	Lamberton	NTN	Minnesota Pollution Control Agency	07/96
Mississippi				
MS22	Oak Grove		Southern Company/Atmospheric Research and Analysis, Inc	06/00
Missouri				
MO46	Mingo NWR		Missouri Department of Natural Resources	03/02
Montana				
MT05	Glacier NP - Fire Weather Station	NTN	National Park Service - Air Resources Division	10/03

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Nevada				
NV02	Lesperance Ranch		EPA/University of Nevada - Reno	02/03
NV99	Gibb's Ranch		EPA/University of Nevada - Reno	02/03
New Mexico				
NM10	Caballo		USGS/New Mexico State University	05/97
New York				
NY20	Huntington Wildlife	NTN	NYS ERDA/State University of New York - Syracuse	12/99
NY68	Biscuit Brook	NTN	NYS ERDA/State University of New York - Syracuse	03/04
North Carolina				
NC08	Waccamaw State Park		North Carolina Dept of Environment & Natural Resources	*12/95
NC42	Pettigrew State Park		North Carolina Dept of Environment & Natural Resources	*12/95
North Dakota				
ND01	Lostwood NWR		US Environmental Protection Agency	11/03
Oklahoma				
OK99	Stilwell		EPA/Cherokee Nation	04/03
Oregon				
OR01	Beaverton		US Geological Survey	04/03
OR10	H. J. Andrews Experimental Forest	NTN	US Geological Survey	12/02
Pennsylvania				
PA00	Arendtsville	NTN	PA Dept of Environmental Protection/Penn State University	11/00
PA13	Allegheny Portage Railroad NHS		PA Dept of Environmental Protection/Penn State University	01/97
PA30	Erie		PA Dept of Environmental Protection/Penn State University	06/00
PA37	Holbrook		Electric Power Research Institute	05/99
PA47	Millersville	NTN	PA Dept of Environmental Protection/Penn State University	11/02
PA60	Valley Forge		PA Dept of Environmental Protection/Penn State University	11/99
PA72	Milford	NTN	PA Dept of Environmental Protection/Penn State University	09/00
PA90	Hills Creek State Park		PA Dept of Environmental Protection/Penn State University	01/97
South Carolina				
SC05	Cape Romaine NWR	NTN	US Fish and Wildlife Service - Air Quality Branch	03/04
SC19	Congaree Swamp		South Carolina Dept of Health & Environmental Control	*12/95
Tennessee				
TN11	Great Smoky Mountains NP-Elkmont	NTN	National Park Service - Air Resources Division	01/02
Texas				
TX21	Longview	NTN	Texas Commission on Environmental Quality	*12/95
TX50	Fort Worth		EPA/City of Fort Worth Dept. of Enviromental Management	08/01
Virginia				
VA08	Culpeper		US Geological Survey	11/02
VA28	Shenandoah NP-Big Meadows	NTN	National Park Service - Air Resources Division	10/02
Vermont				
VT99	Underhill	AIRMoN/NTN	NOAA-ARL/University of Vermont	07/04
Washington				
WA18	Seattle - NOAA		NADP/Illinois State Water Survey	03/96
Wisconsin				
*WI08	Brule River		Wisconsin Department of Natural Resources	*12/95
WI09	Popple River	NTN	Wisconsin Department of Natural Resources	12/95
WI22	Milwaukee		US Geological Survey	10/02
WI31	Devil's Lake		Wisconsin Department of Natural Resources	01/01
WI32	Middle Village	NTN	EPA/Menominee Indian Tribe	01/02
WI36	Trout Lake	NTN	Wisconsin Department of Natural Resources	*12/95
WI99	Lake Geneva	NTN	Wisconsin Department of Natural Resources	01/97
Wyoming				
WY07	Yellowstone NP - Yellowstone Lake		National Park Service - Air Resources Division	02/02

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
CANADA				
Newfoundland				
NF09	Cormak		Environment Canada - Atmospheric Environment Branch	05/00
Nova Scotia				
NS01	Kejimkujik NP		Environment Canada - Atmospheric Environment Branch	07/96
Ontario				
ON07	Egbert		Environment Canada	03/00
Quebec				
PQ04	Saint Anicet		Environment Canada-Public Works and Government Service	04/98
PQ05	Mingan		Environment Canada-Public Works and Government Service	04/98
Saskatchewan				
SK12	Bratt's Lake BSRN		Environment Canada - Prairie and Northern Region	05/01

*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.

PROCEEDINGS NOTES

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