附錄2、Proceedings

2016 Scientific Symposium and Fall Meeting
Deposition: What Does the Future Hold?

October 31–November 4, 2016
Santa Fe, New Mexico

National Atmospheric Deposition Program

Conference Schedule

Monday, October 31, 2016	
TDEP Committee Meeting	1:00 – 5:00 pm
Tuesday, November 1, 2016	
Registration	7:30 - 2:45 pm
Continental Breakfast	7:30 – 8:30 am
Joint Subcommittee Meeting	8:30 - 10:00 am
Break	10:00 – 10:15 am
Subcommittee Meeting (3)	10:15 - 12:15 pm
Lunch (On your own)	12:00– 1:30 pm
Joint Subcommittee Meeting	1:30 - 2:45 pm
Break	2:45 - 3:00 pm
Executive Committee Meeting	3:00 - 6:00 pm
Wednesday, November 2, 2016	
Registration	7:30 - 5:25 pm
Continental Breakfast	7:30 – 8:30 am
Welcome, Introduction and Overview	8:30 – 8:40 am
Annual State of the NADP Report	8:40 - 9:00 am
Session #1 (3 speakers)	9:00 – 10:00 am
Break	10:00 – 10:15 am
Session #2 (6 speakers)	10:15 – 12:15 pm
Lunch (On your own) or SCUAM Lunch Meeting	12:15– 1:30 pm
Session #3 (1 speaker)	1:30 – 2:00 pm
Session #4 (4 speakers)	2:00 – 3:30 pm
Break	3:30 - 3:45 pm
Session #5 (5 speakers)	3:45 - 5:25 pm
Break	5:25 - 6:00 pm
Poster Reception	6:00 - 8:00 pm
Thursday, November 3, 2016	
Registration	7:30 - 5:25 pm
Continental Breakfast	7:30 – 8:30 am
Opening Remarks and Overview	8:20 - 8:30 am
Keynote Speaker	8:30 - 9:15 am
Session #6 (3 speakers)	9:15 - 10:15 am
Break	10:15 - 10:30 am
Session #7 (5 speakers)	10:30 - 12:10 pm
Lunch (On your own)	12:10 - 1:30 pm
Session #8 (4 speakers)	1:30 - 2:50 pm
Break	2:50 - 3:05 pm
Session #9 (7 speakers)	3:05 - 5:25 pm
Friday, November 4, 2016	
Registration	7:30 - 11:30 am
Continental Breakfast	7:30 – 8:30 am
Opening Remarks and Overview	8:20 - 8:30 am
Session #10 (5 speakers)	8:30 - 10:10 am
Session #11 (4 speakers)	10:10 - 11:30 am
Break	11:30-12:00 pm
Optional Field Trip –Bandelier National Monument	12:00 - 6:00 pm

NADP 2016
Technical Committee Meeting

October 31–November 4, 2016
Santa Fe, New Mexico

Scientific Symposium Chair
Donna Schwede
U.S. EPA

PROCEEDINGS

Prepared by

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October 2016

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Technical Session 4: Atmospheric Mercury Deposition and Cycling in Aquatic and Terrestrial Ecosystems

Technical Session 5: Atmospheric Mercury Deposition and Cycling in Aquatic and Terrestrial Ecosystems (continued)

Technical Session 6: Deposition and Critical Loads Estimates in Tribal Communities

Technical Session 7: Atmospheric Deposition Model Evaluation, Uncertainty, and Measurement Model Fusion

Technical Session 8: Atmospheric Deposition Modeling

Technical Session 9: Novel Measurements of Atmospheric Deposition and Ecosystem Processes

Technical Session 10: Influences of Trends and Climate Change on Critical Loads

Technical Session 11: Urban Atmospheric Chemistry and Deposition

Poster Session (arranged in alphabetical order by first author)

NADP Scientific Symposium Agenda

NADP Annual Meeting and Scientific Symposium
Santa Fe, New Mexico
October 31–November 4, 2016

Monday, October 31, 2016		**Room Location**
1:00 p.m.–5:00 p.m.	TDEP	Lumpkins Ballroom North

Tuesday, November 1, 2016

Open All Day	Registration Desk	Mezzanine
8:30 a.m.–10:00 a.m.	Joint Subcommittee Meeting	Lumpkins Ballroom North
10:00 a.m.–10:15 a.m.	Break	Mezzanine
10:15 a.m.–12:00 p.m.	Subcommittee Meetings	
	Network Operations	Lumpkins Ballroom North
	Ecological Response and Outreach	Stiha Room
	Critical Loads	Lumpkins Ballroom South
12:00 p.m. –1:30 p.m.	Lunch on your own	
1:30 p.m. –2:45 p.m.	Joint Subcommittee Meeting	Lumpkins Ballroom North
2:45 p.m. –3:00 p.m.	Break	Mezzanine
3:00 p.m. –6:00 p.m.	Executive Committee Meeting	Lumpkins Ballroom South

Wednesday, November 2, 2016		**Room Location**
Open All Day	Registration/Office	Mezzanine
8:30 a.m.– 9:00 a.m.	**Welcome, Program Office Report** **Awards and Announcements**	Lumpkins Ballroom South

Donna Schwede: NADP-Vice Chair, Symposium Chair
U.S. Environmental Protection Agency
David Gay: NADP Coordinator
Emily Elliott: NADP Chair
University of Pittsburgh

Wednesday, November 2, 2016	**Room Location**
	Lumpkins Ballroom

Technical Session 1:	**Connections between Visibility and Atmospheric** Session Chair: Scott Copeland Colorado State University/USDA Forest Service
9:00 a.m. – 9:20 a.m.	**Estimating Temporal Trends in Biogenically Formed Secondary Organic Aerosols Resulting From Reduction in Atmospheric Aerosol Water Content across the Continental United States** William Malm, Colorado State University
9:20 a.m. – 9:40 a.m.	**Early Onset of the Spring Fine Dust Season in the Southwestern United States** Jenny Hand, Colorado State University
9:40 a.m. – 10:00 a.m.	**A Non-destructive, Inexpensive Method for Predicting TOR OC and EC in the IMPROVE and CSN Networks using Infrared Spectra** Ann Dillner, University of California, Davis
10:00 a.m. – 10:15 a.m.	Break
Technical Session 2:	**Critical Loads of Atmospheric Deposition, Fire Risk, and Ecosystem Change** Session Chair: Claire O'Dea and Chris Clark USDA Forest Service and National Center for Environmental Assessment, U.S. EPA
10:15 a.m. – 10:35 a.m.	**A Framework to Quantify the Strength of Ecological Links Between Critical Loads of Atmospheric Deposition and Final Ecosystem Services** Michael Bell, National Park Service
10:35 a.m. – 10:55 a.m.	**Ecological Responses to Five Years of Experimental Nitrogen Application in an Upland Jack-pine Stand** Shanti Berryman, Integral Ecology Group
10:55 a.m. – 11:15 a.m.	**Progress in Lichen Based Critical Loads for the Deposition of Fertilizing and Acidifying Air Pollutants in the United States** Linda Geiser, USDA Forest Service

Wednesday, November 2, 2016		**Room Location**
		Lumpkins Ballroom
11:15 a.m. – 11:35 p.m.	**Nitrogen Deposition Critical Loads for Phytoplankton Biomass Nutrient Limitation Shifts in Western U.S. Mountain Lakes** Jason Williams, Washington State University	
11:35 a.m. – 11:55 a.m.	**Spatial Patterns in Critical Loads and Exceedance in Forests in the Northeastern U.S.: Using a GIS Tool for Assessing Effects of Nitrogen Deposition** Linda Pardo, USDA Forest Service	
11:55 a.m. – 12:15 p.m.	**Nitrogen and Sulfur Deposition at Selected Federal Class I Areas and Sensitive Class II Areas** Krish Vijayaraghavan, Ramboll Environ	
12:15 p.m. – 1:30 p.m.	Lunch on your own Or Science Committee for Urban Air Monitoring Lunch Meeting – Stiha Room	
Technical Session 3:	**A Summary of the Special Acid Rain 2015 Issue of Atmospheric Environment** Introduction by David Gay NADP	
1:30 p.m. – 2:00 p.m.	**A Summary of the Special Acid Rain 2015 Issue of Atmospheric Environment** Douglas Burns, U.S. Geological Survey	
Technical Session 4:	**Atmospheric Mercury Deposition and Cycling in Aquatic and Terrestrial Ecosystems** Session Chair: Doug Burns U.S. Geological Survey	
2:00 p.m. – 2:30 p.m.	**Spatial Patterns and Temporal Trends in Atmospheric Deposition, Surface Water and Fish Mercury in the Adirondack Region of New York** Charles Driscoll, Syracuse University	
2:30 p.m. – 2:50 p.m.	**Atmospheric Mercury Deposition from Litterfall in the Eastern USA** Martin Risch, U.S. Geological Survey	

Wednesday, November 2, 2016		**Room Location**
		Lumpkins Ballroom
2:50 p.m. – 3:10 p.m.	**Six-year Mercury Dry Deposition Estimates to Various Land Covers Surrounding Monitoring Sites in North America** Leiming Zhang, Environment and Climate Change Canada	
3:10 p.m. – 3:30 p.m.	**Temporal Trends of Mercury in Precipitation from the Mercury Deposition Network: 2008-2015** Peter Weiss-Penzias, UC Santa Cruz	
3:30 p.m. – 3:45 p.m.	Break	
Technical Session 5:	**Atmospheric Mercury Deposition and Cycling in Aquatic and Terrestrial Ecosystems (continued)** Session Chair: Marty Risch U.S. Geological Survey	
3:45p.m. – 4:05 p.m.	**Wet and Speciated Hg Dry Deposition to a Tropical Mountain-top Site in Central Taiwan** Guey-Rong Sheu, National Central University	
4:05 p.m. – 4:25 p.m.	**Ambient Atmospheric Measurements of Speciated Mercury and Total Gaseous Mercury in the Canadian Oil Sands Region** Matthew Parsons, Environment and Climate Change Canada	
4:25 p.m. – 4:45 p.m.	**Evaluation of GOM Measurement Artifacts at the Mauna Loa AMNet Site** Winston Luke, NOAA/ARL	
4:45 p.m. – 5:05 p.m.	**Source Attribution of Mercury Deposition to the Four Corners Region, Southwestern United States** Leonard Levin, Electric Power Research Institute	
5:05 p.m. – 5:25 p.m.	**Decision Tree Analysis to Identify Factors that Impact Monomethylmercury Fraction in Wet Deposition** Dennis Jackson, Savannah River National Laboratory	
5:25 p.m. – 6:00 p.m.	Break	

Wednesday, November 2, 2016		**Room Location**
6:00 p.m. – 8:00 p.m.	**Poster Session and Reception**	Santa Fe/New Mexico Rooms

Thursday, November 3, 2016		**Room Location**
Open All Day	Registration/Office	Mezzanine

Thursday, November 3, 2016		**Room Location**
		Lumpkins Ballroom
8:20 a.m. – 8:30 a.m.	**Opening Remarks, Announcements, and Overview of Day 2** Donna Schwede, NADP -Vice Chair, U.S. Environmental Protection Agency	
8:30 a.m. – 9:15 a.m.	**Keynote Address** Atmospheric Deposition Research through an Indigenous Lense or Understanding the Natural LAW: Land, Air and Water Dr. Dan Wildcat, Haskell Indian Nations University	
Technical Session 6:	**Deposition and Critical Loads Estimates in Tribal Communities** Session Chair: Scott Weir Kansas Dept. of Health & Environment (Retired)	
9:15 a.m. – 9:35 a.m.	**Assessing Critical Loads Nationwide and in Relationship to Native American Tribal Lands** Jason Lynch, U.S. EPA	
9:35 a.m. – 9:55 a.m.	**Characterizing Dust Sources of Southern Colorado Plateau Tribal Land** Margaret Redsteer, U.S. Geological Survey	
9:55 a.m. – 10:15 a.m.	**Building Tribal Partnerships with Low Cost Small-Footprint Ambient Monitoring Sites** Melissa Puchalski, U.S. Environmental Protection Agency	
10:15 a.m. – 10:30 a.m.	Break	
Technical Session 7:	**Atmospheric Deposition Model Evaluation, Uncertainty, and Measurement Model Fusion** Session Chair: Amanda Cole and Bret Schichtel Environment and Climate Change Canada and National Park Service	
10:30 a.m. – 10:50 a.m.	**Regional Refined Grid Modeling of Acidic and Mercury Deposition over Northeastern US and the Contribution of New York Power Point Sources.** Michael Ku, New York State Department of Environmental Conservation, Albany NY	

Thursday, November 3, 2016		**Room Location**
		Lumpkins Ballroom
10:50 a.m. – 11:10 a.m.	**Twelve Years of Nitrogen Deposition Gap? An EMEP4UK Model Analysis** Massimo Vieno, Centre for Ecology & Hydrology	
11:10 a.m. – 11:30 p.m.	**Evaluation and Intercomparison of Five Major Dry Deposition Algorithms in North America** Zhiyong Wu, CIRA, Air Quality Research Division, Science and Technology Branch, Environment and Climate Change Canada	
11:30 a.m. – 11:50 p.m.	**Towards Binational Concentration and Deposition Maps of Nitrogen and Sulphur with ADAGIO (Atmospheric Deposition Analysis Generated by Optimal Interpolation of Observations)** Amanda Cole, Environment and Climate Change Canada	
11:50 p.m. – 12:10 p.m.	**Quantifying Uncertainty in Total Deposition Estimates** Gary Lear, U.S. EPA	
12:10 p.m. – 1:30 p.m.	Lunch on your own	
Technical Session 8:	**Atmospheric Deposition Modeling** Session Chair: Leiming Zhang Environment and Climate Change Canada	
1:30 p.m. – 1:50 p.m.	**Sulfate and Nitrate in Wet Atmospheric Deposition in the Gulf of Mexico and Possible Source Regions of Their Precursors** Rodolfo Sosa E., Universidad Nacional Autonoma de México (UNAM)	
1:50 p.m. - 2:10 p.m.	**Particulate Ammonium Contribution to Total Deposition** Rich Scheffe, U.S. EPA	
2:10 p.m. – 2:30 p.m.	**Investigation of Ammonia Air-surface Exchange Processes in a Deciduous Montane Forest in the Southeastern U.S.** John Walker, US EPA	
2:30 p.m. – 2:50 p.m.	**Twist on a Back Trajectory Technique to Examine Wet Deposition Events** Kristi Gebhart, National Park Service	
2:50 p.m. – 3:05 p.m.	Break	

Thursday, November 3, 2016 **Room Location**

Lumpkins Ballroom

Technical Session 9: **Novel Measurements of Atmospheric Deposition and Ecosystem Processes**
Session Chair: Emily Elliott and John Walker
University of Pittsburgh and U.S. EPA

3:05 p.m. – 3:25 p.m. **Deposition and Re-emission of Ammonia by Dew**
Jeffrey Collett, Colorado State University

3:25 p.m. – 3:45 p.m. **Wet Atmospheric Deposition of Organic Carbon Across Pennsylvania: Rates and Relation to Inorganic Elements of Precipitation Chemistry**
Lidiia Iavorivska, Pennsylvania State University

3:45p.m. – 4:05 p.m. **Atmospheric Reactive Nitrogen in Northern Colorado**
Katherine Benedict, Colorado State University

4:05 p.m. – 4:25 p.m. **Atmosphere-biosphere Exchange of Biogenic Oxidized Volatile Organic Compounds over a Southeastern United States Forest**
Tran Nguyen, University of California, Davis

4:25 p.m. – 4:45 p.m. **A Comparison of AMoN Measurements with Localized, Arrayed Passive NH_3 Samplers in Northern Utah**
Randy Martin, Utah State University

4:45 p.m. – 5:05 p.m. **Temporal Variability of Ammonia Fluxes from Open-path, Eddy Covariance Measurements**
Mark Zondlo, Princeton University

5:05 p.m. – 5:25 p.m. **Measurements of NOy and HNO_3 at a Rural-Forested Site in the Southern Appalachians**
Eric Edgerton, ARA, Inc

Friday, November 4, 2016 **Room Location**

Open A.M. Session Registration/Office Mezzanine

Friday, November 4, 2016 **Room Location**

Lumpkins Ballroom

8:20 a.m. – 8:30 a.m. **Opening Remarks, Announcements, and Overview of Day 3**
Donna Schwede, NADP -Vice Chair,
U.S. Environmental Protection Agency

Technical Session 10: **Influences of Trends and Climate Change on Critical Loads**
Session Chairs: Jason Lynch and Tamara Blett
U.S. EPA and National Park Service

8:30 a.m. – 8:50 a.m. **Reactive Nitrogen Emissions from Marcellus Shale Natural Gas Extraction**
Emily Elliott, University of Pittsburgh

8:50 a.m. – 9:10 a.m. **Modeling the Long-term Deposition Trends in US over 1990—2010 and Their Impacts on the Ecosystem Assessment**
Yuqiang Zhang, U.S. EPA

9:10 a.m. – 9:30 a.m. **Sulfur, Nitrogen, and Climate Change Biogeochemical and Empirical Effects Modeling in the Eastern United States: What are We Doing and Why Might Anybody Care?**
T.J. Sullivan, E & S Environmental

9:30 a.m. – 9:50 a.m. **Recent Advances for Critical Loads of Herbaceous Species and Influences of Climate Change**
Christopher Clark, National Center for Environmental Assessment, U.S. EPA

9:50 a.m. – 10:10 a.m. **Assessing Regional Impacts of N Deposition on Forests through Species Specific Responses**
Kevin Horn, Virginia Tech - Department of Forest Resources and Environmental Conservation

Technical Session 11: **Urban Atmospheric Chemistry and Deposition**
Session Chair: Tom Whitlow
Cornell University

10:10 a.m. – 10:30 a.m. **Sulfur and Nitrogen Compounds in Wet Atmospheric Deposition and in Ambient Air as Indicators of Emissions Reduction Strategies at Mexico City**
Humberto Bravo A., Universidad Nacional Autonoma de México (UNAM)

Friday, November 4, 2016	**Room Location**
	Lumpkins Ballroom
10:30 a.m. – 10:50 a.m.	**Variation and Drivers of Nitrogen Deposition, Cycling, and Loss throughout an Urban Metropolitan Area** Stephen Decina, Boston University
10:50 a.m. – 11:10 a.m.	**Distribution of Atmospheric Reactive Nitrogen in Indo-Gangetic Plains (India)** Saumya Singh, School of Environmental Sciences Jawaharlal Nehru University
11:10 a.m. – 11:30 a.m.	**Atmospheric Deposition of Nitrogen in New York City and Boston** Thomas Whitlow, Cornell University
11:30 a.m.	Adjourn
12:00 p.m. – 6:00 p.m.	Optional Field Trip – Bandelier National Monument -NADP Monitoring Site

2016 NADP SITE OPERATOR AWARDS

National Atmospheric Deposition Program Operator Awards

5 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
AL99 - AMoN	Mack Smith	Sand Mountain Agricultural Experiment Station	U.S. EPA - Clean Air Markets	03/29/11
AR03 - AMoN	Harrell Beckwith	Caddo Valley	U.S. EPA - Clean Air Markets	03/01/11
CA28 - NTN	Kevin Mazzocco	Kings River	USDA FS- Pacific Southwest Research Station	04/24/07
CA44 - AMoN	Katy Warner	Yosemite NP - Turtleback Dome	National Park Service - ARD	03/15/11
CA67 - AMoN	Stacy Munson	Joshua Tree National Park - Black Rock	National Park Service - ARD	03/01/11
CO02 - NTN	Jennifer Morse	Niwot Saddle	NSF/INSTAAR-Univ of Colorado	06/05/84
CO90- NTN	Jennifer Morse	NiwotRidge - Southeast	NSF/INSTAAR-Univ of Colorado	01/24/06
CO94 - NTN	Jennifer Morse	Sugarloaf	U.S. EPA - Clean Air Markets	11/04/86
CT15 - NTN	Pam Brundage	Abington	U.S. EPA - Clean Air Markets	01/26/99
CT15 - AMoN	Pam Brundage	Abington	U.S. EPA - Clean Air Markets	03/29/11
FL11 - AMoN	L. Phillip Navarro	Everglades National Park	National Park Service - ARD	03/15/11
FL19 - AMoN	Charles Vogt		U.S. EPA - Clean Air Markets	04/26/11
FL96 -MDN	Raymond Beghtel	Pensacola	Southern Company/Atmospheric Research & Analysis	12/28/10
GA20 - NTN	Andy Jones	Bellville	U.S. EPA - Clean Air Markets	04/26/83
GA41 - AMoN	Matthews Evans	Georgia Station	U.S. EPA - Clean Air Markets	06/07/11

5 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
IL37 - AMoN	Steve Evans		U.S. EPA - Clean Air Markets	04/26/11
IL46 - AMoN	Walter Steiner	Alhambra	U.S. EPA - Clean Air Markets	03/03/11
KS31 - AMoN	Rosemary Ramundo	Konza Prairie	U.S. EPA - Clean Air Markets	03/01/11
KY03 - AMoN	Belinda Warden	Mackville	U.S. EPA - Clean Air Markets	03/01/11
NC08 - MDN	Robert Hodges	Waccamaw State Park	North Carolina Department of Environment and Natural Resources Air Quality Section	02/27/96
NC26 - AMoN	Hazel Perry	Candor	U.S. EPA - Clean Air Markets	04/26/11
NE99 - NTN	Dan Hitch	North Platte Agricultural Experimnet Station	U.S. Geological Survey	09/24/85
NJ98 - AMoN	John Kukon		U.S. EPA - Clean Air Markets	03/01/11
NS01-MDN	Margo DeLong	Kejimkujik National Park	Environment Canada	07/02/96
NY96 - NTN	Andrew Seal	Cedar Beach, Southold	Suffolk County DHS-Peconic Estuary Program/EPA	11/25/03
OH54 - AMoN	Sally Hammond	Deer Creek State Park	U.S. EPA - Clean Air Markets	03/01/11
OK99 - MDN	Jacque Adam	Stilwell	EPA/Cherokee Nation	04/29/03
OK99 - AMoN	Jacque Adam	Stilwell	U.S. EPA - Clean Air Markets	10/30/07
PA02 - NTN	Kevin Horner	Crooked Creek	Pennsylvania DEP/Penn State University	07/27/11
PA13 - NTN	Kevin Horner	Allegheny Portage Railroad National Historic Site	Pennsylvania DEP/Penn State University	07/26/11

5 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
PA29 - AMoN	Bob Ishman	Kane Experimental Forest	U.S. EPA - Clean Air Markets	03/08/11
PA60 - NTN	Kevin Horner	Valley Forge	Pennsylvania DEP/Penn State University	07/26/11
PA71 - NTN	Kevin Horner	Little Buffalo	Pennsylvania DEP/Penn State University	07/26/11
PA83 - NTN	Kevin Horner	Laurel Hill	Pennsylvania DEP/Penn State University	07/26/11
PA90 - NTN	Kevin Horner	Hills Creek State Park	Pennsylvania DEP/Penn State University	07/26/11
WA03 - MDN	Doug Sternbeck	Makah National Fish Hatchery	National Park Service - ARD	03/02/07
WA98 - NTN	Christine Plourde	Columbia River Gorge	USFS-Pacific Northwest Region	05/07/02
WI07 - AMNet	David Grande	Horicon Marsh	LADCO	01/02/11
WI35 - AMoN	Fred Emstrom	Perkinstown	U.S. EPA - Clean Air Markets	03/29/11
WY02 - NTN	Steve Renner	Sinks Canyon	Bureau of Land Management	08/21/84

10 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
AB14 - MDN	Dean Yustak	Genesee	Intrinsik Environmental Sciences	07/18/06
CA94 - NTN	David Jones	Converse Flats	USDA Forest Service	05/09/06
CA94 - MDN	David Jones	Converse Flats	USDA Forest Service	04/20/06
CO93- NTN	Nicolai Bencke	Buffalo Pass - Dry Lake	USDA Forest Service	10/14/86
CO97 - NTN	Nicolai Bencke	Buffalo Pass - Summit Lake	USDA Forest Service	02/07/84
CO97 - MDN	Nicolai Bencke	Buffalo Pass - Summit Lake	USDA Forest Service	09/29/98
MN01 - NTN	Jim Krueger	Cedar Creek	Minnesota Pollution Control Agency	12/31/96
NY10 - NTN	Sherri Mason	Chautauqua	U.S. Geological Survey	06/10/80
OK01 - MDN	Bryan Sims	McGee Creek	Oklahoma Department of Environmental Quality	10/31/06
TN04 - NTN	Roger Russell	Speedwell	U.S. EPA - Clean Air Markets	01/26/99

15 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
CA50 - NTN	Faerthen Felix	Sagehen Creek	U.S. Geological Survey	11/06/2001
CAN5 - NTN	Serge D'Amour		U.S. Geological Survey	10/02/2001
CO00 - NTN	Ted Smith	Alamosa	U.S. Geological Survey	04/22/1980
GA09 - NTN	Ronald Phernetton	Okefenokee National Wildlife Refuge	U.S. Fish and Wildlife Service - Air Quality Bureau	06/03/1997
NY22 - NTN	Angela Benedict-Dunr	Akwesasne Mohawk-Fort Covingto	U.S. EPA - Clean Air Markets	08/18/1999
NY99 - NTN	Matthew Munson	West Point	U.S. Geological Survey	09/13/1983

20 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
CA99 - NTN	Katy Warner	Yosemite National Park-Hodgdon Meadow	National Park Service - ARD	12/08/1981
KS32 - NTN	Curt Sauer	Lake Scott State Park	U.S. Geological Survey	03/27/1984
KY35 - NTN	Jeff Stamper	Clark State Fish Hatchery	U.S. Geological Survey	08/30/1983
MN27 - NTN	Lee Klossner	Lamberton	Minnesota Pollution Control Agency	01/02/1979
TX10 - NTN	Terry Rossignol	Attwater Prairie Chicken National Wildlife Refuge	U.S. Geological Survey	07/03/1984
WA24 - NTN	Robert Barry	Palouse Conservation Farm	U.S. Geological Survey	08/20/1985
WI08 - MDN	Ron Perala	Brule River	Wisconsin Department of Natural Resources	03/05/1996

25 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
CO22 - NTN	Mark Lindquist	Pawnee	National Park Service - ARD	05/22/1979
CO91 - NTN	Todd Pitcher	Wolf Creek Pass	USDA Forest Service	05/26/1992
OH49 - NTN	Mike Franko	Caldwell	U.S. Geological Survey	09/26/1978

30 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
IL11 - NTN	Michael Snider	Bondville	U.S. EPA - Clean Air Markets	02/27/1979
KS07 - NTN	Dan Mosier	Farlington Fish Hatchery	U.S. Geological Survey	03/27/1984
MI99 - NTN	David Toczydlowski	Chassell	USDA Forest Service	02/15/1983
VT01 - NTN	Dan Taylor	Bennington	U.S. Geological Survey	04/28/1981

35 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
MI09 - NTN	Robert Vande Kopple	Douglas Lake	SAES-Michigan State Univ	07/03/1979

KEYNOTE SPEAKER

DR. DAN WILDCAT
HASKELL INDIAN NATIONS UNIVERSITY

Daniel R. Wildcat
Director of the Haskell Environmental Research Studies (HERS) Center and Indigenous & American Indian Studies faculty member at Haskell Indian Nations University

Brief Biography

Daniel R. Wildcat is a Yuchi member of the Muscogee Nation of Oklahoma. He is director of the Haskell Environmental Research Studies (HERS) Center and member of the Indigenous & American Indian Studies Program at Haskell Indian Nations University in Lawrence, Kansas. In 2013 he was the Gordon Russell visiting professor of Native American Studies at Dartmouth College. He has served as adjunct faculty for the Bloch School - UMKC for the past decade. Dr. Wildcat received B.A. and M.A. degrees in sociology from the University of Kansas and an interdisciplinary Ph.D. from the University of Missouri at Kansas City. He has taught at Haskell for 30 years.

Dr. Wildcat has been an invited speaker on American Indian worldviews at Goddard Space Flight Center, the Smithsonian National Museum of the American Indian, Harvard Medical School, Dartmouth College, University of Kansas Medical School, Kansas State University, University of California (Riverside) and many other institutions of higher education. Dr. Wildcat frequently speaks to community groups and organizations on the issue of cultural diversity. In 1992 Dr. Wildcat was honored with the Heart Peace Award by the Kansas City organization, The Future Is Now, for his efforts to promote world peace and cultural diversity.

In 1994 he helped form a partnership with the Hazardous Substance Research Center at Kansas State University to create the Haskell Environmental Research Studies (HERS) Center as a non-profit Native American research center to facilitate: 1) technology transfer to tribal governments and Native communities, 2) transfer of accurate environmental information to tribes, and 3) research opportunities to tribal college faculty and students throughout the United States.

In 1996 Dr. Wildcat helped plan and organize an American Indian educational program to celebrate the 25th anniversary of Earth Day when he moderated a live nationally broadcast dialogue between traditional American Indian Elders and American Indian scientists and engineers about the way we must live if we are to ensure a healthy planet for our children. Dr. Wildcat helped plan and design a four-part video series entitled All Things Are Connected: The Circle of Life (1997), which dealt with land, air, water and biological issues related to environmental science and policy issues facing Native nations.

Dr. Wildcat's recent activities have revolved around forming the American Indian and Alaska Native Climate Change Working Group: a tribal college-centered network of individuals and organizations working on climate change issues. In 2008 he helped organize the *Planning for Seven Generations* climate change conference sponsored by the National Center for Atmospheric Research. Dr. Wildcat also co-chaired with Winona La Duke at the national Native Peoples-Native Homelands Climate Change Workshop at the Mystic Lake Hotel & Casino, November 18-21, 2009.

He is the author and editor of several books: ***Power and Place: Indian Education In America***, with Vine Deloria, Jr.; Destroying ***Dogma: Vine Deloria's Legacy on Intellectual America***, with Steve Pavlik. His most recent book, ***Red Alert: Saving the Planet with Indigenous Knowledge***, suggests current global climate change issues will require the exercise of indigenous ingenuity - ***indigenuity*** - and wisdom if humankind is to reduce the ecological damage well underway.

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TECHNICAL SESSION 1:
CONNECTIONS BETWEEN VISIBILITY AND ATMOSPHERIC

Session Chair: Scott Copeland,
Colorado State University/
USDA Forest Service

Estimating Temporal Trends in Biogenically Formed Secondary Organic Aerosols Resulting From Reduction in Atmospheric Aerosol Water Content Across the Continental United States

William Malm[1], Bret A. Schichtel[2] and Jennifer L. Hand[3]

Particulate organic carbon (POM) aerosols contribute significantly to nitrogen deposition. POM is about 30-40% of PM2.5 in the Eastern United States (U.S.) and more than 50% in parts of the Western U.S. Therefore understanding the fate and origin of the PM2.5 POM aerosol is essential to mitigating its contribution to atmospheric deposition, visibility, health, and climate forcing. To some degree apportionment of POM in the form of secondary organic aerosols (SOA) to an emission source is an ill-defined problem in that volatile organic carbon (VOC) gases may have their origin in biogenic emissions while the oxidation of that VOC and formation of SOA particles may be dependent of anthropogenic emissions from a variety of sources. A recent analysis has suggested that atmospheric aerosol water, in the form of water absorbed by hygroscopic aerosols, such as sulfates and nitrates, is the dominant pathway for the formation of SOA in parts of the Eastern United States. Therefore, as aerosols, such as sulfates, and associated aerosol water decrease over time it is expected that a concurrent decrease in SOA should occur.

In this analysis trends in POM over time, collected over a 16 year time period in the IMPROVE monitoring program, are explored. It is shown that particulate organic mass (POM) is decreasing in almost all parts the U.S. and in all seasons of the year. The decrease in POM over time has its origins in changing emissions from wild and prescribed fire and reductions in mobile and industrial sources and possible in reductions in atmospheric aerosol water. An approximation of temporal trends in biogenically derived SOA across the U.S. is developed by accounting for the fraction of POM that is biogenic and addressing how anthropogenic POM has changed over time and across the U.S. The analysis suggests that in much of the Eastern U.S. a significant portion of the decrease in summer-time POM aerosol is associated with fire and vegetative emissions. A concurrent reduction in sulfate aerosol is consistent with the hypothesis that reducing aerosol water results in reductions in biogenically derived SOA.

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Early onset of the spring fine dust season in the southwestern United States

Jenny Hand[1], W. H. White[2], K. A. Gebhart[3], N. P. Hyslop[4], T. E. Gill[5] and B. A. Schichtel[6]

The highest fine dust concentrations (mineral particles with aerodynamic diameters less than 2.5 µm) in the United States typically occur in spring in the Southwest. Contributions of fine dust to total PM2.5 mass reaches 50% or higher at rural and remote Interagency Monitoring of Protected Visual Environments (IMPROVE) sites during spring months. Trend analyses indicate that springtime regional mean fine dust concentrations have increased from 1995 through 2014, especially in March (5.4 % yr^{-1}, $p < 0.01$). This increase reflects an earlier onset of the spring dust season across the Southwest by one to two weeks over the 20-year time period. March dust concentrations were strongly correlated with the Pacific Decadal Oscillation (PDO) index ($r = -0.65$, $p<0.01$), which was mostly in its negative phase from 2007 through 2014, during which the region was drier, windier, and less vegetated. The positive spring trend and its association with large-scale climate variability have several important implications for visibility, particulate matter, health effects, and the hydrologic cycle in the region.

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A Non-destructive, Inexpensive Method for Predicting TOR OC and EC in the IMPROVE and CSN networks using Infrared Spectra

Ann Dillner[1], Andrew T. Weakley[2], Giulia Ruggeri[3], Matteo Reggente[4] and Satoshi Takahama[5]

The Interagency Monitoring of Protected Visual Environments (IMPROVE) network and the Chemical Speciation Network (CSN) are speciation particulate matter monitoring networks in the U.S. IMPROVE is located primarily in Class 1 visibility areas and CSN is located in urban and suburban areas. Carbonaceous aerosol, which can be 50% or more of the particulate matter mass, is measured in both networks using thermal optical reflectance (TOR) on quartz filter samples. We have developed a less expensive, non-destructive method using Fourier transform-infrared spectroscopy (FT-IR) and partial least squares regression to predict TOR organic (OC) and elemental carbon (EC).

Infrared spectra are obtained from PTFE filters that are routinely collected in parallel with the quartz filters in both monitoring networks. Using two-thirds of samples collected at seven IMPROVE sites in 2011, FT-IR can reproduce TOR OC and EC with good accuracy and precision on par with collocated TOR measurements. Using the 2011 calibrations and samples collected at 17 sites in 2013, we show that FT-IR can measure OC and EC in different years and at different sites than the samples used in the calibration. For two sites (Fresno, CA and South Korea IMPROVE sites) that likely have different aerosol composition than the primarily rural US sites used in the calibration, making separate calibrations with these sites or adding these sites to the 2011 calibration improved the prediction of TOR OC and EC. Using a sparse calibration method, we show that TOR OC is predicted using a suite of organic functional groups and that EC is predicted using a few organic functional groups and C-C stretch in ring-structured compounds.

We developed TOR OC and EC calibrations for the CSN network using samples collected at 10 sites during 2013. Although the aerosol mass is generally higher in urban areas than in rural areas, samplers used in CSN have lower flowrates and larger filters causing the mass interrogated by the FT-IR beam to be on average ~5 times less in CSN than in IMPROVE. For OC, the predictions results are very similar to IMPROVE and for the EC the relative error is similar to IMPROVE but the R^2 drops from 0.96 to 0.85. Using processed FT-IR spectra, we determine that organic carbon functional groups are used to predict TOR OC and that organic and elemental carbon functional groups and a factor related to pyrolyzed carbon are used to predict EC.

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TECHNICAL SESSION 2:
CRITICAL LOADS OF ATMOSPHERIC DEPOSITION, FIRE RISK, AND ECOSYSTEM CHANGE

Session Chairs: Claire O'Dea and Chris Clark,
USDA Forest Service and National
Center for Environmental Assessment,
U.S. EPA

A framework to quantify the strength of ecological links between critical loads of atmospheric deposition and final ecosystem services

Michael Bell[1], Jennifer Phelan[2] and Tamara Blett[3]

Anthropogenic deposition of nitrogen and sulfur can lead to the acidification and eutrophication of ecosystems. Scientists generally rely on biological indicators of deposition to signal when ecosystem conditions have been altered beyond an acceptable amount and label this value the critical load. However, these biological indicators are not always capable of being directly related to ecosystem services (ecosystem components that provide benefits to humans). Therefore, we developed the STEPS (**ST**ressor – **E**cological **P**roduction function – Final Ecosystem **S**ervices) Framework to link changes in a biological indicator of a critical load to a final ecosystem service. The STEPS framework produces "chains" of ecological components that explore the breath of impacts in the change due to exceedance of a critical load. Chains are comprised of the biological indicator, the ecological production function (EPF) which uses ecological components to link the biological indicator to an ecological endpoint that is a final ecosystem service, as well as the user group who directly uses, appreciates, or values the component. The framework uses a qualitative score (High, Medium, Low) for the Strength of Science (SOS) for the relationship between each of the components in the EPF to identify research gaps and prioritize decision making based on what research has been completed.

We tested the STEPS Framework within a workshop setting using the Final Ecosystem Goods and Services Classification System (FEGS-CS) to describe final ecosystem services. We identified chains for four modes of ecological response to deposition: aquatic acidification, aquatic eutrophication, terrestrial acidification, and terrestrial eutrophication. The workshop participants identified 169 unique EPFs linking a change in a biological indicator to a FEGS. After accounting for the multiple beneficiaries of each FEGS, we ended with a total of 1073 chains. The SOS scores allow managers and policy makers may use this information to understand uncertainty imbedded in responses to critical loads, or select chains with strong scientific foundations for quantitative assessment and subsequent valuation. The chains are also being used to tell compelling stories to translate the impacts of air pollution to a beneficiary-specific audience by using the ecological component that the group values and linking it back to the exceedance of a critical load via the EPFs. The results of the analysis can be transferred to the social science community enabling them to apply valuation measures to multiple or selected chains, providing a more comprehensive analysis of the effects of anthropogenic stressors on measures of human well-being.

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Ecological responses to five years of experimental nitrogen application in an upland jack-pine stand

Shanti Berryman[1], Justin Straker[2], Natalie Melaschenko[3], Kevan Berg[4], Shaun Watmough[5] and Andrew McDonough[6]

A five-year experimental study was conducted to evaluate the response of an upland jack-pine (*Pinus banksiana*) forest to elevated levels of nitrogen (N) deposition applied as ammonium nitrate above the forest canopy in Northern Alberta. N deposition in the region is expected to increase with industrial expansion of oil sands activities, and there is regional interest to set N critical loads for sensitive ecosystems in this boreal region. Jack-pine uplands represent one regional ecosystem that is expected to be sensitive to N deposition.

In this study, N was applied as NH_4NO_3 above a jack-pine canopy via helicopter, five times annually for five years (2010-2015) at dosages equivalent to 5, 10, 15, 20 and 25 kg N ha^{-1} yr^{-1}. Over the course of the study, we observed that approximately 35% of the applied N was retained in the canopy while 65% reached understory vegetation dominated by lichens and mosses.

We measured a significant increase in tissue N concentrations of common ground lichens (*Cladonia mitis* and *C. stellaris*) and ground moss (*Pleurozium schreberi*) as well as epiphytic lichens (*Hypogymnia physodes* and *Evernia mesomorpha).* On an annual basis, the applied N was primarily captured in the lichen and moss understory, where the predominant ground cover is *C. mitis*. In the highest treatments, N concentrations in *C. mitis* were 1.5-2.5 times greater than pre-treatment values. Peak N concentrations in the ground moss *Pleurozium schreberi* (1.4%) were consistent with values recorded in Europe at comparable N deposition rates, and indicate that a threshold of N saturation was reached 3 years into the treatment. N concentrations in vascular plants were not affected by the treatments, and we observed no changes in community composition for vascular and non-vascular plants. Chlorophyll levels in *C. mitis* increased with N treatment, but there was no indication of toxicity or decline in *C. mitis* health, and decomposition and growth of the lichen remained consistent.

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Progress in Lichen Based Critical Loads for the Deposition of Fertilizing and Acidifying Air Pollutants in the United States

Linda Geiser[1]

Critical loads provide a science-based tool for land managers and regulators charged with protecting the environment from air pollution. Epiphytic lichens are very sensitive to air pollution and provide CLs that can be considered broadly protective of forest vegetation. Here I review the history and evolution of lichen-based critical loads and associated factors affecting their reliability. Over the past decade US Forest Service scientists have utilized national and regional scale lichen survey data to relate community composition to measured and modeled nitrogen and sulfur deposition, climate, and forest type. Initially lichen CLs were established for specific ecoregions and critical loads were allowed to vary with climate variables or they did not account for other environmental variables. In recent work we recognize that at broad geographic scales, lichen communities are shaped by climate even in the absence of air pollution. If the response threshold (community composition) is allowed to vary with climate, single national critical loads for N and S can be selected independent of ecoregion. Uncertainties surrounding critical loads estimates have been reduced by improvements in deposition and climate modeling; larger more representative response datasets; and new techniques in community analysis. While individual response curves (effect of deposition on species abundance) are intuitively easy to understand and relate to ecological roles; community response is a more reliable and robust indicator of deposition effects.

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Nitrogen Deposition Critical Loads for Phytoplankton Biomass Nutrient Limitation Shifts in Western U.S. Mountain Lakes

Jason Williams[1], Jason Lynch[2] and Jasmine Saros[3]

Anthropogenic atmospheric nitrogen deposition has the potential to alter remote mountain lake ecosystems in the Western United States. Relatively low amounts of Nitrogen (N) deposition may increase lake N concentrations, stimulate algal growth, and affect whether N or phosphorus (P) limits algal growth, leading to changes in the lake's productivity, specie richness and diversity. We calculated critical loads for deposition-induced changes in nutrient limitation of algal biomass growth in Western U.S. mountain lakes using a three-step approach. First, a database with nitrogen and phosphorus water chemistry data for over 3,000 lakes in the Western U.S was assembled from existing data sources. Second, biomass responses to experimental N and P enrichment in bioassays from 50 Western U.S. mountain lakes were synthesized to define threshold dissolved inorganic nitrogen to total phosphorus (DIN:TP) mass ratios at which shifts in phytoplankton biomass nutrient limitation occur. Third, the water chemistry and chemical threshold data were combined with modeled N deposition estimates to calculate critical loads using two different empirical approaches and one model-based approach. Empirical approaches related modeled nitrogen deposition rates directly to phytoplankton biomass responses in nutrient enrichment bioassays with and without considering effects of watershed characteristics on lake DIN:TP. The model-based approach calculates a critical load as the N deposition rate that causes experimentally-defined DIN:TP chemical threshold to be exceeded while accounting for effects of watershed characteristics on lake DIN:TP. Preliminary results indicate an empirically-based critical load of 3.4 kg total N ha^{-1} yr^{-1}. Contrasting results of these different approaches yields useful information about the data types, methodologies, and uncertainties relevant to critical load calculations for nutrient enrichment effects in mountain lakes.

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Spatial patterns in critical loads and exceedance in forests in the northeastern U.S.: using a GIS tool for assessing effects of nitrogen deposition

Linda Pardo[1], Molly Robin-Abbott[2], Claire B. O'Dea[3], Jennifer Pontius[4] and Jason A. Coombs[5]

Maintaining commercially important tree species, as well as species valued for ecological, social, and cultural reasons, is becoming increasingly challenging in the northeastern U.S. due to the significant threats impacting ecosystem health and sustainability over the long term, in particular climate change and nitrogen (N) deposition. We developed a GIS-based tool, Nitrogen Critical Loads Assessment by Site (N-CLAS), to evaluate the impact of multiple stressors (N deposition and climate change) simultaneously for species of management concern on public and private forest lands. In addition to calculating species-specific critical loads, N-CLAS is designed to take into account the impact of site abiotic factors on the response of trees to N deposition. The abiotic modifying factors include, precipitation, temperature (e.g., January T, July T, May-September T), and soil characteristics. Application of N-CLAS across the northeastern U.S. allows us to evaluate which areas and tree species are most susceptible to impacts from N deposition. We can determine the critical load and exceedance for individual tree species or all the species present. We have incorporated climate change scenarios in order to explore the interaction between climate change and nitrogen deposition. Thus, we are also able to determine the fraction of the region that is susceptible to detrimental impacts of N deposition under projected climate scenarios. Use of this tool provides resource managers with a simple way to incorporate the current state-of-the-science knowledge into their planning and management decisions.

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Nitrogen and Sulfur Deposition at selected Federal Class I areas and Sensitive Class II areas

Krish Vijayaraghavan[1], John Grant[2], Zhen Liu[3], Tejas Shah[4], Jaegun Jung[5] and Ralph Morris[6]

The atmospheric deposition of nitrogen and sulfur is an important consideration for the preservation of Air Quality Related Values in Federal Class I areas and sensitive Class II areas such as wilderness areas, national monuments and wildlife refuges and other lands managed by the BLM, NPS, USFS and USFWS. In this paper, we investigate the deposition of nitrogen and sulfur compounds to selected Class I and sensitive Class II areas and tribal areas in New Mexico using the advanced photochemical grid model, CAMx. The model treats the atmospheric chemistry, dispersion and wet and dry deposition of nitrogen and sulfur emissions from diverse anthropogenic sources including oil and gas projects, mining, electrical generating units, other industrial sources, mobile sources, agricultural and other area sources, and wildfires and biogenic emissions. Current and estimated future deposition rates are studied following changes in emissions of atmospheric precursors and compared with critical loads for nitrogen and sulfur deposition to assess the impact on these sensitive ecosystems.

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TECHNICAL SESSION 3:
A SUMMARY OF THE SPECIAL ACID RAIN 2015 ISSUE OF ATMOSPHERIC ENVIRONMENT

Session Chair: David Gay
NADP

A Summary of the Special Acid Rain 2015 Issue of Atmospheric Environment

Douglas Burns[1], Julian Aherne[2], David Gay[3] and Christopher Lehmann[4]

The International Acid Rain Conference was held on Oct. 19 – 23, 2015 in Rochester, New York and attended by 350 scientists from across the globe. A special Acid Rain 2015 issue of the journal Atmospheric Environment will be published based on the conference that is expected to include more than 30 papers representing authors and studies from North America, Europe, Asia, and Africa. The papers are divided about equally between studies of patterns and trends in atmospheric deposition and studies of the effects of atmospheric deposition on ecosystems. The special issue will highlight some common themes and summarize recent advances in scientific understanding of spatial and temporal trends in deposition and patterns of ecosystem responses. Sulfate (SO_4^{2-}) concentrations in precipitation and rates of deposition have declined globally in recent decades at all sites where long-term and continuous measurements are available, including in Asia. These decreases in SO_4^{2-} are largely attributed to policies that have reduced emissions from coal-fired electric generation facilities and other major sources. Concentrations and deposition of nitrogen (N) species are more varied with decreasing, unchanging, and increasing trends reported at various locations over the past 2-3 decades. Nitrate (NO_3^-) concentrations generally show more reported declines than do those of reduced N species such as ammonia (NH_3) and ammonium (NH_4^+). The fraction of total N in atmospheric deposition that consists of reduced N is increasing at many sites around the globe, and locations in the US and Asia report increasing trends in reduced N concentrations. These patterns can be attributed to increases in reduced N emissions in some cases, but declines in the formation of particulate NH_4^+ species resulting from decreases in SO_2 and NO_x emissions are likely contributing to increased NH_3concentrations. Despite several atmospheric deposition monitoring programs in parts of Europe, Asia, and North America, large geographic gaps still exist in many developing regions, and there is a widespread lack of measurements of some key species such as organic carbon, dust, and hydroperoxides as highlighted by papers in the special issue.

Surface waters in regions such as the Adirondacks in the northeastern US, southeastern Canada, and southern Norway are showing increases in pH and ANC as well as decreases in toxic inorganic monomeric aluminum in response to long-term decreases in S and N deposition. However, the recovery of surface water chemistry has not matched that of deposition, which is a result, in part, of long-term losses of base cations from soils that are inherently slow to recover. Recovery from surface water acidification is predicted to eventually promote a parallel recovery in sensitive aquatic ecosystems, but thus far, fish communities in North America and Europe have shown little or only marginal improvements. In Asia, little surface water acidification occurs, but soils in forested regions of China are experiencing ongoing acidification. Ecosystem effects of N deposition that include enhanced NO_3^- leaching and decreased biodiversity of plant communities remain a concern across North America, Europe, and Asia. However, some encouraging case studies exist such as the likely contribution of decreasing atmospheric N deposition to decreasing N loads to the Chesapeake Bay. Critical loads studies are becoming more widespread across the globe as a means of informing the success of air pollutant policies at achieving ecosystem effects goals as reflected by several papers in the special issue.

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TECHNICAL SESSION 4:
ATMOSPHERIC MERCURY DEPOSITION AND CYCLING IN AQUATIC AND TERRESTRIAL ECOSYSTEMS

Session Chair: Doug Burns,
U.S. Geological Survey

Spatial patterns and temporal trends in atmospheric deposition, surface water and fish mercury in the Adirondack region of New York

Charles Driscoll[1], Stephen Boucher[2], Jacqueline Gerson[3], Mariah Taylor[4], Amy Shaw[5] and Eric Paul[6]

While the Adirondack region of New York experiences modest atmospheric mercury deposition, it is considered a biological mercury hotspot. Wet and litter mercury deposition, and stream and lake mercury are monitored at Huntington Forest in the central Adirondacks through NADP. We have not found changes in wet mercury deposition since measurements were initiated in 2000, but litter mercury appears to be decreasing. Arbutus Lake inlet and outlet samples at Huntington Forest show long-term decreases in concentrations and fluxes of both total and methyl mercury, despite increases in dissolved organic carbon. More broadly we have examined spatial patterns of mercury in standard length yellow perch (*Perca flavescens*) across Adirondack lakes. We find elevated concentrations of mercury in fish, particularly in the western Adirondack. Mercury concentrations in yellow perch are particularly elevated in lakes with low pH and acid neutralizing capacity. Fish mercury concentrations also increase with total and methyl mercury concentrations and monomeric aluminum fractions. We did not observe any relationship between fish mercury and lake concentrations of dissolved organic carbon, although we did find strong correlations between total and methyl mercury concentrations and dissolved organic carbon in the water column. Finally, there are 17 Adirondack lakes with multiple year observations of fish mercury in yellow perch dating back to the early 1990s. Trend analysis indicates that all but one of these lakes are showing statistically significant decreases in mercury concentration at a mean rate of 0.007 ± 0.004 μg g^{-1} ww.

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Atmospheric Mercury Deposition from Litterfall in the Eastern USA

Martin Risch[1], John Dewild[2], David Gay[3], Leiming Zhang[4], Elizabeth Boyer[5] and David Krabbenhoft[6]

Atmospheric mercury deposition from litterfall was found to be an important route for mercury loading to forest ecosystems in the eastern USA. Mercury (Hg) monitoring of autumn litterfall was done for six years at 27 National Atmospheric Deposition Program (NADP) sites in deciduous and mixed deciduous-coniferous forests in 16 states. Hg concentrations and the dry weight litterfall catch in samples from passive collectors were used to compute annual litterfall Hg deposition. Monitoring results from 2007–2009 and 2012–2014 indicated annual litterfall Hg deposition rates were equal to or higher than annual wet Hg deposition rates in 70 percent of the records at co-located NADP precipitation-monitoring sites. Annual littrfall Hg deposition was a median 11.7 and a maximum 23.4 micrograms per square meter per year. Annual litterfall Hg deposition measurements were closely aligned with modeled dry deposition of gaseous elemental, oxidized, and particulate-bound Hg air concentrations at co-located NADP atmospheric monitoring sites. These findings indicate atmospheric Hg loading to forest ecosystems can be measured more completely and dry Hg deposition models are improved when litterfall Hg deposition data are included. A long-term, litterfall Hg monitoring network can be a cost-effective and useful complement to precipitation Hg and atmospheric Hg monitoring networks.

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Six-year mercury dry deposition estimates to various land covers surrounding monitoring sites in North America

Leiming Zhang[1]

Dry deposition of atmospheric mercury (Hg) to various land covers surrounding 24 sites in North America was estimated for the years 2009 to 2014, making use of the monitored air concentrations of gaseous elemental Hg (GEM), gaseous oxidized Hg (GOM), and particulate-bound Hg (PBM). Depending on location, multi-year mean annual Hg dry deposition was estimated to range from 5.1 to 23.8 $\mu g\ m^{-2}\ yr^{-1}$ to forested canopies, 2.6 to 20.8 $\mu g\ m^{-2}$ to non-forest vegetated canopies, 2.4 to 11.2 $\mu g\ m^{-2}\ yr^{-1}$ to urban and built up land covers, and 1.0 to 3.2 $\mu g\ m^{-2}\ yr^{-1}$ to water surfaces. GEM was the main contributor to Hg dry deposition over vegetated surfaces, accounting for 31 to 98% among the sites and land covers, while GOM plus PBM became more important over non-vegetated surfaces. The dominant role of GEM in the Hg dry deposition budget over vegetated surfaces was due to the relatively low concentrations of oxidized Hg. Seasonally-averaged Hg deposition was the highest in the winter and the spring and the lowest in the summer over most land covers. Interannual variations in the estimated annual Hg dry deposition were in the range of a factor of 1.3 to 2.0 at the six sites that had six complete years of data. The estimated dry deposition was assessed using litterfall measurements and modeled Hg emissions at the regional scale, and was demonstrated to be reliable although with large uncertainties.

This study concludes that in the rural or remote environment in North America, annual mercury dry deposition to vegetated surfaces is dominated by leaf uptake of elemental gaseous mercury. This is contrary to what was commonly assumed in earlier studies which frequently omitted GEM dry deposition as an important process. The percentage contribution of GEM dry deposition in the total mercury dry deposition is expected to increase should mercury emissions in North America continue declining, considering that background GEM will not decrease as fast as anthropogenic emissions. Net dry deposition dominated the air-surface flux exchange in all of the seasons except in the summer months at half of the sites where net emissions from soil and leaf stomata dominated. Data for longer periods are needed to evaluate the effectiveness of Hg emission control policies and to assess the trends of atmospheric mercury dry deposition for subsequent ecosystem impact studies.

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Temporal trends of mercury in precipitation from the Mercury Deposition Network: 2008-2015

Peter Weiss-Penzias[1] and David Gay[2]

We present an analysis of temporal trends in weekly mercury (Hg) concentrations in precipitation collected at 84 sites by the Mercury Deposition Network (MDN) over 2008-2015. Our previous work with MDN data over time periods ending in 2013 showed that 53%/0% of sites in the MDN had significant negative/positive trends in mercury wet deposition for 1997–2013, whereas for 2008–2013, 6%/30% of sites had significant negative/positive trends in mercury wet deposition. This work concluded that over the more recent time period, there were many more sites with significant positive trends than sites with negative trends. The increase in the number of sites with positive trends was primarily found in the Plains and Rocky Mountain regions. In this current work we have included the most recent MDN Hg concentration data through 2015 to assess whether this pattern has continued. For Hg concentration data in precipitation from 2008-2015, we found that 12%/19% of the sites in the MDN had significant negative/positive trends in Hg concentration in precipitation (i.e. there were fewer sites with significant positive trends using the newer data set). The Plains region continued to have the highest proportion of MDN sites with significant positive trends (6 of 12), and a regional statistical test showed that the Plains was the only region having a significant upward trend in Hg concentration in precipitation. In general, the western half of the continent contained the majority of sites with trends (both significant and not significant) > +2% per year (12 out of 27) compared to the sites in the east (5 out of 57). Preliminary analysis also shows that he regional temporal patterns in Hg concentrations are correlated with patterns in the Palmer Drought Severity Index (PDSI); maximum regional Hg concentrations correspond to the maximum number of states in a region with at least one county having a PDSI designation of "extreme drought".

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TECHNICAL SESSION 5:
ATMOSPHERIC MERCURY DEPOSITION AND CYCLING IN AQUATIC AND TERRESTRIAL ECOSYSTEMS (CONTINUED)

Session Chair: Marty Risch,
U.S. Geological Survey

Wet and speciated Hg dry deposition to a tropical mountain-top site in central Taiwan

Guey-Rong Sheu[1], Da-Wei Lin[2], Neng-Huei Lin[3] and Leiming Zhang[4]

Taiwan is located downwind of the East Asian continent, which is the largest anthropogenic mercury (Hg) source region globally. Speciated atmospheric Hg has been measured since mid-April 2006 and weekly rainwater samples have been collected for total Hg analyses since early 2009 at the Lulin Atmospheric Background Station (LABS; 120.87°E, 23.47°N, 2862 m a.s.l.) in central Taiwan. Here we report and characterize the wet and dry deposition of Hg on LABS in 2010. The annual rainfall at LABS was 3173.2 mm in 2010. A total of 36 weekly rainwater samples were collected for Hg analysis with an annual volume-weighted mean Hg concentration of 8.8 ng L^{-1}. The annual wet deposition flux was 33.7 µg m^{-2}. Seasonal VWM concentrations and wet deposition flux were both higher in summer than in the other seasons. The high summertime wet deposition flux was primarily a result of elevated amount of rainfall (1632 mm) and to a lesser extent, higher rainwater Hg concentration (12.7 ng L^{-1}). As there is no anthropogenic Hg emission source near the LABS, the high summertime rainwater Hg concentration hints the importance of Hg^0 oxidation and/or scavenging of upper-altitude Hg(II) by deep convection. Speciated Hg dry depositions were estimated based on a model calculation. For the year of 2010, dry deposition fluxes of GEM, RGM, and PHg were estimated to be 58.8, 10.6, and 0.1 µg m^{-2}, respectively, with a total dry flux of 69.5 µg m^{-2}. Wet deposition dominated in summer/fall, but dry deposition dominated in spring/winter. Nonetheless, overall wet deposition was more important than the dry deposition of RGM plus PHg at this tropical mountain-top site because of abundant rainfall. Concentration-weighted trajectory (CWT) approach was applied to identify potential source regions of each atmospheric Hg species. Southwest and Southeast China and northern Indochina Peninsula were the common major source regions of GEM, RGM and PHg. An additional source region for GEM was identified extending from northeast China along the coastal region of east China. Moreover, air from the South China Sea and the Pacific Ocean could also be enriched with RGM, suggesting sources other than anthropogenic emissions, such as Hg^0 oxidation.

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Ambient atmospheric measurements of speciated mercury and total gaseous mercury in the Canadian Oil Sands Region

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As part of the Canada-Alberta Joint Oil Sands Monitoring program, ambient concentrations of atmospheric mercury are currently measured at two sites within the Canadian oil sands region near Fort McMurray and Fort McKay, Alberta. Speciated mercury—including gaseous elemental mercury (GEM), gaseous oxidized mercury (GOM), particulate bound mercury on $PM_{2.5}$ ($PBM_{2.5}$), and particulate bound mercury on PM_{10} (PBM_{10})—and total gaseous mercury (TGM) were measured near Fort McKay, Alberta; TGM was also measured within the town site of Fort McMurray, Alberta. TGM data are reported for the period of October 2010 – December 2015; speciated mercury data are reported for the period of September 2014 – December 2015. TGM data (October 2010 – December 2015) from the Canadian oil sands region are compared to historical TGM measurements from across Alberta and Saskatchewan since 1998, including historical measurements within the Canadian oil sands region. For sites with five or more years' worth of data, TGM concentration data show statistically significant decreasing long-term trends of -0.7 to -5.5 % yr^{-1}. Speciated atmospheric mercury results, with shorter periods of record, will be compared to other speciated mercury monitoring data from Alberta.

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Evaluation of GOM Measurement Artifacts at the Mauna Loa AMNet Site

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Recent laboratory and field research has documented and explored the biases and inaccuracies of the measurement of gaseous oxidized mercury (GOM) compounds using KCl-coated denuders. We report on the development of a simple, automated GOM calibration source and its deployment at NOAA/Air Resources Laboratory's Atmospheric Mercury Network (AMNet) site at the Mauna Loa Observatory (MLO) on the island of Hawaii. NOAA/ARL has developed a permeation-tube based calibration source with an extremely simple flow path that minimizes surface adsorptive effects and losses. The source was used to inject $HgBr_2$ into one of two side-by-side Tekran® mercury speciation systems at MLO to characterize GOM measurement accuracy under a variety of atmospheric conditions. Due to its unique topography and meteorology, MLO experiences katabatic (upslope/downslope) mesoscale flow superimposed on the synoptic trade wind circulation of the tropics. Water vapor, ozone, and other trace atmospheric constituents often display pronounced diurnal variations at the site, which frequently encounters air characteristic of the middle free troposphere at night, and of the tropical marine boundary layer during the day. Results presented here will assist in the better understanding of the biases underlying GOM measurements in global mercury monitoring networks and may allow the development of correction factors for ambient data.

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Source Attribution of Mercury Deposition to the Four Corners Region, Southwestern United States

Leonard Levin[1] and Bob Goldstein[2]

A suite of air quality and watershed models was applied to track the ecosystem contributions of mercury (Hg), as well as arsenic (As), and selenium (Se) from local and global sources to the San Juan River basin in the Four Corners region of the American Southwest. Long-term changes in surface water and fish tissue mercury concentrations were also simulated, out to the year 2074.Atmospheric mercury was modeled using a nested, spatial-scale modeling system comprising GEOS-Chem (global scale) and CMAQ-APT (national and regional) models. Four emission scenarios were modeled, including two growth scenarios for Asian mercury emissions. Results showed that the average mercury deposition over the San Juan basin was 21 $\mu g/m^2$-y. Source contributions to mercury deposition range from 2% to 9% of total deposition prior to post-2016 U.S. controls for air toxics regulatory compliance. Most of the contributions to mercury deposition in the basin are from non-U.S. sources. Watershed simulations showed power plant contributions to fish tissue mercury never exceeded 0.035% during the 85-year model simulation period, even with the long-term growth in fish tissue mercury over that period. Local coal-fired power plants contributed relatively small fractions to mercury deposition (less than 4%) in the basin; background and non-U.S. anthropogenic sources dominated. Fish-tissue mercury levels are projected to increase through 2074 due to growth projections for non-U.S. emission sources. The most important contributor to methylmercury in the lower reaches of the watershed was advection of MeHg produced *in situ* at upstream headwater locations.

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Decision Tree Analysis to Identify Factors that Impact Monomethylmercury Fraction in Wet Deposition

Dennis Jackson[1] and Stephen P. Harris[2]

Numerous processes are postulated for the source of monomethylmercury (MMHg) in wet deposition. Competing theories on the source(s) of MMHg in wet deposition include volatilization of gaseous MMHg, evasion and demethylation of dimethylmercury, and direct methylation of Hg0 in the atmosphere. Hammerschmidt and others (2007) suggest that MMHg may be formed in the atmosphere through a reaction between labile Hg(II) complexes and an unknown methylating agent(s), potentially acetate or similar molecules. In this investigation we apply next generation data mining techniques to explore potential relationships between observations obtained from the NADP's National Trends Network and the Mercury Deposition Network to identify potential factors that may be associated with elevated fractions of MMHg.

In this analysis a partition (decision tree) model was developed using paired weekly data for NADP sites that participate in both the National Trends Network and the Mercury Deposition Network, including the quantification of methyl mercury in precipitation. The partition modeling process recursively partitions data according to a relationship between the independent (NTN results) variables and the dependent (fraction of MMHg) variable, creating a tree of partitions. The analysis process exhaustively searches all possible cuts or groupings of the independent variables to identify cuts or groupings that best predict the dependent variable. These splits (or partitions) of the data are done recursively forming a tree of decision rules until the desired fit is reached.

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TECHNICAL SESSION 6:
DEPOSITION AND CRITICAL LOADS ESTIMATES IN TRIBAL COMMUNITIES

Session Chair: Scott Weir
Kansas Department of Health &
Environment (Retired)

Assessing critical loads nationwide and in relationship to Native American tribal land

Jason Lynch[1] and Clara Funk[2]

Anthropogenic atmospheric nitrogen (N) and sulfur (S) deposition from air pollution have impacted our lakes and streams, forests, grasslands, and lichen communities across the U.S. The good news is that emission reduction programs for sulfur dioxide (SO2) and nitrogen oxide (NOx), such as the Acid Rain Program and Cross-State Air Pollution Rule, have reduced N and S deposition mostly in the eastern U.S., allowing for some ecosystems to begin to recover from air pollution impacts. In some areas of the U.S., the reductions in N and S deposition is now protective of some ecosystem elements. However, N and S deposition for some regions remains high or is increasing, making it hard to know whether current levels of deposition are protective of ecosystems. Here we completed a national assessment using six different critical load endpoints and there exceedances to assess the impact of N and S deposition on our natural ecosystems. Given that Native American tribal lands contain many natural areas, we also compared critical loads and their exceedances on tribal lands to estimated values of the surrounding region and nationwide. Contrasting these results will help to understand whether natural ecosystems on tribal lands are impacted at a higher level than the nationwide average. The critical load endpoints assessed included: forest ecosystems, herbaceous plants, lichens, nitrate leaching, forest soil and surface water acidity. Forest ecosystems, herbaceous plants, lichens, nitrate leaching for N are empirical critical loads based on Pardo et al. 2011. The forest soil and surface water critical loads for acidity are steady-state mass balance critical loads based on multiple approaches and methods. All critical loads are part of the National Critical Load Database (NCLD) developed by the Critical Load of Atmospheric Deposition (CLAD) science committee as part of the National Atmospheric Deposition Program (NADP). Ecological impacts of a given endpoint were assumed to occur when deposition is greater or exceeds the critical load. Critical load exceedances for N and N+S were based on annual values of Total Deposition (Tdep) for the period from 2001-2014. Urban and agriculture lands were excluded from this analysis using National Land Cover Data (NLCD).

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Characterizing Dust Sources of southern Colorado Plateau Tribal Land

Margaret Redsteer[1]

Dust particles of geologic origin are a widely dispersed component of Earth's atmosphere, often observed as plumes originating from arid and semi-arid areas. Those observed on Native lands of the southern Colorado Plateau result in long-range dust transport during synoptic weather events. Resulting dust storms may potentially become common as a consequence of increased aridity from climate change, bringing about catastrophic phenomena that can damage infrastructure, degrade rangeland, and affect transportation through reduced visibility, with a potential to cause tremendous economic losses. Constituents in dust that are transported by these events and may affect human health are diverse, and include soil microorganisms, trace metals and metalloids, radioactive elements, silicates, and alkali salts. The Little Colorado River (LCR) in northeastern Arizona is an important regional source of windblown dust, and transports a large sediment load of sand and silt. A significant decrease in streamflow in the LCR occurred over the 20 century, due to warmer and drier conditions and water supply demands. Currently, only a short segment of the LCR channel, near its confluence with the Colorado River, flows year-round, leaving dry river sediment in and adjacent to most of the river channel during the windy spring. Wind-blown flood deposits from the desiccated river valley are now likely to be a significant source of dust contributing to "dust on snow" events in the southern Colorado Rockies. To estimate potential contributions to dust on snow from this source area, wind deflation was measured in the flood plain during the spring of 2010. Measurements provide an estimate of the volume of silt and clay-sized particles that were transported by wind during five major, well-documented dust events. Three playas associated with the river system contributed 4.41 km of dust during March and April 2010 dust storms, or an average of 0.88 km of dust per wind event. Work is currently underway to produce a database to better characterize these dust sources, and their composition.

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Building Tribal Partnerships with Low Cost Small-Footprint Ambient Monitoring Sites

Melissa Puchalski[1], Timothy Sharac[2], David Schmeltz[3], Christopher Rogers[4], Kevin Mishoe[5] and Kemp Howell[6]

Reactive nitrogen (Nr) is very important pollutant which at the same time plays a very important role on air and water quality, human health and biological diversity. The atmospheric nitrogen deposition can cause acidification and excess eutrophication, which brings damages to the ecosystems. Quantifying the total deposition is US is still a challenge due to the lack of the long-term observation data for the dry deposition.

For this study, we use a comprehensive coupled meteorology-air quality model (WRF-CMAQ) to simulate deposition changes in US over 1990—2010. The WRF-CMAQ model was run for the continental US using a 36km by 36km horizontal grid spacing, by using a consistent emission inventory recently developed by Jia et al., (2013). We found significant decreasing trend for the total inorganic nitrogen over the East and West coast of California, and increasing trend in the East North Central. The decreased total deposition was controlled by the oxidized nitrogen, as a result of the recent consistent NOx emission reductions due to air regulations such as the Clean Air Act and the NOx State Implementation Plan, consistent with other studies (Li et al., 2016; Schwede and Lear, 2014). The increased inorganic nitrogen deposition was dominated by the reduced nitrogen, which was attributed to the unregulated increasing ammonia (NH_3) emissions. The dry and wet inorganic nitrogen deposition trends also have a different spatial patterns: wet deposition was decreasing all over the U.S., while the dry deposition decreased over the East and increased over the Central areas, which was controlled by the increased dry NH_3 deposition. The contribution of the reduced nitrogen to the total nitrogen varies both spatially and temporally: it is usually above 50% in the North Central areas, and below 50% in the East and West of U.S. However we see a significant increasing trend for these contributions all over the U.S. as a result of the NOx emission reductions and ammonia emission increases.

Future effort will be investigated to compare the WRF-CMAQ model results with the estimated total deposition by using the hybrid approach developed by Schwede and Lear (2014). Then we will also quantify the ecosystem effects from the nitrogen deposition changes for the past 20 years on the critical loads and biodiversity.

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TECHNICAL SESSION 7:
ATMOSPHERIC DEPOSITION MODEL EVALUATION, UNCERTAINTY AND MEASUREMENT MODEL FUSION

Session Chairs: Amanda Cole and Bret Schichtel,
Environment and Climate Change
Canada and National Park Service

Regional Refined Grid Modeling of Acidic and Mercury Deposition over Northeastern US and the Contribution of New York Power Point Sources.

Leon Sedefian[1], Michael Ku[2], Kevin Civerolo[3], Winston Hao[4] and Eric Zalewsky[5]

The importance of atmospheric processes and the response of the underlying land and water surface to anthropogenic air pollutant input has been studied considerably and as recent EPA and New York State (NYS) policy and regulatory approaches have emphasized an interest in the interaction of multi-pollutant mixtures, the need for more comprehensive approaches has surfaced. These requirements have been supported by technical documents with heavy reliance on regional photochemical modeling assessments. Many national and NYS requirements affect the emissions and interactions of pollutants from energy production sources such as Energy Generation Units (EGUs) and waste to energy (WTE) facilities. However, technical assessments to carry out these requirements and to understand the multi-pollutant system have not been commensurate with the latest emissions data and the techniques or approaches necessary to properly assess the implementation of these requirements.

The purpose of the current study was to address the limitations in previous regional modeling assessments by refining the previous coarse grid resolutions down to a 4km grid level in an novel application of the Community Multiscale Air Quality (CMAQ) Eulerian grid modeling system on an annual timescale, using the latest available National Emissions Inventory (NEI) for 2011 and Weather Research and Forecasting (WRF) simulated meteorological data. The other emphasis was to determine the contribution of the NYS major power generation sector point sources to the overall acidic and mercury depositions. For mercury, emissions of the elemental, oxidized and particulate species were characterized using available data to properly characterize the contribution of EGUs and WTE facilities.

The results of the CMAQ modeling for annual and some seasonal deposition levels for the 2011NEI and the power sector are presented in graphical forms over the modeling domain and, in particular, over NYS. The results show the importance of both dry and wet deposition for the oxidized form of mercury which has the largest contribution to the total mercury levels. The contribution of the NYS's power sector is deemed relatively small and very localized, with the impact of emissions outside the modeling domain clearly dominating total Hg depositions, confirming the importance of regional transport into the state. For acidic deposition, the importance of wet deposition is noted for sulfates and nitrates, but dry deposition becomes dominant for total sulfur deposition. The larger summer versus winter contributions for sulfate is noted, but for mercury or nitrates, no real distinction by season is found. The emissions from the NYS power sector is determined to have the largest effect in reducing total sulfur deposition, but not for the other species. In addition, projected "future" year reduction in EGUs and other source emissions cause large reductions in both sulfate and nitrate levels. A comparison of wet deposition observations at NADP monitors to CMAQ results indicates remarkably good model performance for mercury and acidic deposition species.

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Twelve years of nitrogen deposition gap? An EMEP4UK model analysis

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An analysis of 12 years of annual nitrogen and sulphur deposition over the UK was carried out comparing atmospheric chemistry transport model (ACTM) results with an observation-derived calculation (CBED). The two deposition estimates agree well for oxidised sulphur, whereas total oxidised nitrogen deposition was underestimated by the ACTM. Possible causes of this discrepancy are the uncertainties of emissions estimates and the simplification in the ACTM aerosols formation. The CBED deposition estimates are less sensitive to uncertainties in the emissions inventory dataset as the UK deposition values are derived from observed deposition and surface concentrations. However, CBED wet deposition may be over-estimated due to dry deposition to the surface of bulk collectors. The UK deposition estimates show a general decline over the 2000-2012 period investigated; for oxidised sulphur $\sim$86 (ACTM) and $\sim$97 (CBED) Gg S yr^{-1}, for oxidised nitrogen $\sim$29 (ACTM) and $\sim$45 (CBED) Gg N yr^{-1}, and for reduced nitrogen $\sim$7 (ACTM) and $\sim$5 (CBED) Gg N yr^{-1}.

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Evaluation and intercomparison of five major dry deposition algorithms in North America

Zhiyong Wu[1], Donna Schwede[2], Robert Vet[3], Mike Shaw[4], Ralf Staebler[5] and Leiming Zhang[6]

Dry deposition of various pollutants needs to be quantified in air quality monitoring networks as well as in chemical transport models. The inferential method is the most commonly used approach in which the dry deposition velocity (V_d) is empirically parameterized as a function of meteorological and biological conditions and pollutant species' chemical properties. Earlier model intercomparison studies suggested that existing dry deposition algorithms produce quite different V_d values, e.g., up to a factor of 2 for monthly to annual average values for ozone, and sulfur and nitrogen species (Flechard et al., 2011; Schwede et al., 2011; Wu et al., 2011). To further evaluate model discrepancies using available flux data, this study compared the five dry deposition algorithms commonly used in North America and evaluated the models using five-year $V_d(O_3)$ and $V_d(SO_2)$ data generated from concentration gradient measurements above a temperate mixed forest in Canada. The five algorithms include: (1) the one used in the Canadian Air and Precipitation Monitoring Network (CAPMoN) and several Canadian air quality models based on Zhang et al. (2003), (2) the one used in the US Clean Air Status and Trends Network (CASTNET) based on Meyers et al. (1998), (3) the one used in the Community Multiscale Air Quality (CMAQ) model described in Pleim and Ran (2011), (4) the Noah land surface model coupled with a photosynthesis-based Gas Exchange Model (Noah-GEM) described in Wu et al. (2011), and (5) the Wesely (1989) scheme, which is still widely used in many air-quality models. All algorithms were driven by the consistent on-site meteorology and with the same input parameters (e.g., leaf area index, roughness length, canopy height, etc.). The magnitudes of model uncertainties were quantified, and dominant factors causing the discrepancies were explored.

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Towards binational concentration and deposition maps of nitrogen and sulphur with ADAGIO (Atmospheric Deposition Analysis Generated by optimal Interpolation of Observations)

Amanda Cole[1], Alain Robichaud[2], Mike D. Moran[3], Mike Shaw[4], Alexandru Lupu[5], Guy Roy[6], Vincent Fortin[7] and Robert Vet[8]

The goal of Environment and Climate Change Canada's ADAGIO project (Atmospheric Deposition Analysis Generated by optimal Interpolation of Observations) is to generate improved maps of wet, dry and total annual deposition of oxidized and reduced nitrogen (N) and sulphur (S) in Canada and the United States by combining observed and modeled data. Established measurements of wet deposition and/or air concentrations of deposited compounds provide the most accurate atmospheric deposition values in regions with dense coverage, but they are too sparse to provide reliable regional estimates of deposition for large areas of the continent and do not include all relevant species. Alternatively, atmospheric models that include meteorology, emissions, transport, chemistry and deposition of key N and S compounds provide complete spatial coverage and the ability to account for non-linear effects of meteorology and chemistry, but have varying degrees of bias and uncertainty in their predicted concentrations and fluxes. This project uses optimal interpolation techniques to combine the different advantages of measurements and models. Gridded seasonal precipitation amounts have been generated using the Canadian Precipitation Analysis (CaPA), in which all available precipitation data sets are used to adjust precipitation amounts predicted by Environment Canada's Global Environmental Multiscale (GEM) numerical weather prediction model. Concentrations of N and S in precipitation are separately optimized using precipitation chemistry measurements from multiple Canadian and U.S. networks to perform optimal interpolation on concentration fields predicted by the in-line regional air quality model GEM-MACH (-Modelling Air quality and Chemistry). Similarly, surface air concentrations of particulate and gaseous N and S species will be optimized based on GEM-MACH output and network data. Effective dry deposition velocities will be obtained from GEM-MACH accumulated deposition amounts. The techniques are being developed using 2010 as a test year and will be applied to additional years in the future. Future directions may also include the incorporation of satellite measurements in the concentration analysis, and integration of ADAGIO methods and results with the USEPA's Total Deposition (TDEP) program.

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Quantifying Uncertainty in Total Deposition Estimates

Gary G. Lear[1]

Atmospheric deposition of nitrogen and sulfur causes many deleterious effects on ecosystems including acidification and excess eutrophication. Assessments to support development of strategies to mitigate these effects require spatially and temporally continuous values of nitrogen and sulfur deposition. Members of NADP's Total Deposition Science Committee (TDEP) developed an approach for estimating dry deposition using ambient concentration data from air monitoring networks such as the Clean Air Status and Trends Network (CASTNET) and NADP's Ammonia Monitoring Network (AMoN), and modeled dry deposition velocities and flux data from the Community Multiscale Air Quality (CMAQ) model. These dry deposition values are then combined with wet deposition values from the NADP National Trends Network (NTN) to estimate values of total deposition of sulfur and nitrogen. Although this approach presumably reduces the overall error due to estimating ambient concentrations at monitoring locations compared with using modeled values alone, additional uncertainty is introduced at interstitial spaces due to interpolation error and other assumptions in the approach. This talk will summarize efforts to quantify the components of this added uncertainty and hopefully provide guidance in further refinements of the TDEP approach.

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TECHNICAL SESSION 8: ATMOSPHERIC DEPOSITION MODELING

Session Chair: Leiming Zhang,
Environment and Climate Change
Canada

Sulfate and nitrate in wet atmospheric deposition in the Gulf of Mexico and possible source regions of their precursors

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The Gulf of Mexico has important sources of acid rain precursors, both on land and at sea, so that is very important study of the chemical composition of the wet atmospheric deposition in this region. For several years in the coast of the United States it has evaluated the chemical composition of rain, resulting acidic values. Studies on the Mexican coast have recorded the presence of acid rain since 2003. In relation to acid rain, pH determination it is essential, in addition to the composition of sulfates and nitrates that are formed from its main precursors, sulfur dioxide and nitrogen oxides, respectively. The aim of this study was to evaluate pH, sulfate and nitrate concentrations in wet atmospheric deposition, collected daily from 2003 to 2014 in a sampling site located in the coast of Mexico (La Mancha) and compare the registered values, with the NADP sampling sites located in the coast of the Gulf of Mexico from Texas to Florida.

HYSPLIT back trajectory model was applied in order to identify the regions where the emissions sources of acid rain precursors are located. Trajectories showed an important transport to the sampling site from the East during rainy season (June-October). The region located east to "La Mancha" is the Gulf of Mexico presenting offshore operations for the exploration and production of petroleum. The annual VWM pH in wet deposition at "La Mancha" sampling site was in the range of 4.78 to 5.40 during the study period (2003-2014) and for the year 2014 was 5.01, which is similar for the USA sites; the VWM concentration of SO_4^{2-} was in the range of 16 to 32 μeq/L, and for the last year was 26 μeq/L, which is similar than the higher level registered in the USA at TX10 site; the VWM concentration of NO_3^- was in the range of 4 to 15 μeq/L and for 2014 was 6 μeq/L, which is lower than in the USA sites. The ratio SO_4^{2-}/NO_3^- found for the site in Mexico in 2014 was 4, being the highest value compared to other sites in the Gulf of Mexico whose ratios were between 1.25 and 1.7. Therefore it is important to pay attention to the sulfur dioxide emission sources in Mexico. It is recommended to extend the atmospheric deposition sampling to other sites in Mexico and Cuba.

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Particulate ammonium contribution to total deposition

Rich Scheffe[1], Jesse Bash[2], James Kelly[3], Bret Schictel[4], Donna Schwede[5] and Jason Lynch[6]

There has been a wealth of evidence over the last decade illustrating the rising importance of reduced inorganic nitrogen (NHx = ammonia gas, NH3, plus particulate ammonium, p-NH4) in the overall atmospheric mass balance and deposition of nitrogen as emissions of oxidized nitrogen have decreased throughout a period of stable or increasing NH3 emissions. In addition, the fraction of ambient ammonia relative to p-NH4 generally has risen as a result of decreases in both oxides of nitrogen and sulfur emissions. EPA plans to consider ecological effects related to deposition of nitrogen, of which NHx is a contributing component, in the review of secondary National Ambient Air Quality Standards (NAAQS) for oxides of nitrogen and sulfur (NOx/SOx standard). Although these ecological effects are associated with total nitrogen deposition, it will be important to understand the emissions sources contributing to the total nitrogen deposition and to understand how much of the total nitrogen deposition is from deposition of NHx versus other nitrogen species. Because p-NH4 contributes to nitrogen deposition and can also be a significant component of particulate matter, there is a potential overlap in addressing nitrogen based deposition effects in the secondary PM and NOx/SOx NAAQS. Consequently, there is a policy interest in quantifying the contribution of p-NH4 to total nitrogen deposition. While dry deposition of p-NH4 is calculated through a variety of modeling approaches, the amount of precipitation based NH4 results from a variety of transfer processes of ambient p-NH4 and NH3 to the aqueous phase without delineating the relative contributions of ambient p-NH4 and NH3. Preliminary results of a simple method utilizing available outputs from a chemical transport model (CTM) are used to demonstrate the relative contribution of p-NH4 to total nitrogen deposition and spur discussion of techniques to refine future assessments.

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Investigation of ammonia air-surface exchange processes in a deciduous montane forest in the southeastern U.S.

John Walker[1], Xi Chen[2], Donna Schwede[3], Ryan Daly[4], Christopher Oishi[5] and Melissa Puchalski[6]

Recent assessments of atmospheric deposition in North America note the increasing importance of reduced ($NH_x = NH_3 + NH_4^+$) forms of nitrogen (N) relative to oxidized forms. This shift in in the composition of inorganic nitrogen deposition has both ecological and policy implications. Deposition budgets developed from inferential models applied at the landscape scale, as well as regional and global chemical transport models, indicate that NH_3 dry deposition contributes a significant portion of inorganic N deposition in many areas. However, the bidirectional NH_3 flux algorithms employed in these models have not been extensively evaluated for North American conditions (e.g, atmospheric chemistry, meteorology, biogeochemistry). Further understanding of the processes controlling NH_3 air-surface exchange in natural systems is critically needed. Based on preliminary results from the Southern Appalachian Nitrogen Deposition Study (SANDS), this presentation examines processes of NH_3 air-surface exchange in a deciduous montane forest at the Coweeta Hydrologic Laboratory in western North Carolina. A combination of measurements and modeling are used to investigate net fluxes of NH_3 above the forest and sources and sinks of NH_3within the canopy and forest floor. Measurements of biogeochemical NH_4^+ pools are used to characterize emission potential and NH_3 compensation points of canopy foliage (i.e., green vegetation), leaf litter, and soil and their relation to NH_3 fluxes. Differences in bidirectional flux modeling results using generalized versus site-specific parameterizations of foliage versus soil processes are addressed along with recommendations for model improvements. Next steps for further processing of SANDS datasets are also discussed.

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Twist on a Back Trajectory Technique to Examine Wet Deposition Events

Kristi Gebhart[1], Jim Cheatham[2], Kristi Morris[3] and John Vimont[4]

April 2013 had unusually high levels of Nitrogen wet deposition at two National Acid Deposition National Trends Network (NADP/NTN) sites in Rocky Mountain National Park, Colorado. Both sites, Beaver Meadows and Loch Vale, have long data records dating to the 1980s, making it possible to examine annual and seasonal trends in concentrations, deposition, and meteorology to better understand the conditions that existed during various levels deposition.

Hourly five-day ensemble back trajectories were generated for Beaver Meadows and Loch Vale for 1980-2015 to examine transport pathways under various sets of conditions including, all times, Aprils only, hours with and without precipitation, various levels of Nitrogen deposition and combinations of these. In addition to the standard statistical and graphical analyses of back trajectories, a new technique was developed to better visualize transport differences under various conditions. This is to generate a map of how unusual it was to receive air masses from upwind areas as compared to average conditions. This allows easy visualization of areas that contribute in both common and rare ways during various conditions and uses an easy to understand metric, the Z score, for how unusual that transport was. The Z score is the number of standard deviations from the mean transport condition.

Results show that April and July have the greatest precipitation at these sites, with April more likely to have synoptic scale storms and July more likely to have convective storms. Only about 7% of hours at Beaver Meadows and 12% at the higher elevation, Loch Vale, have precipitation. Though the predominant wind direction at both sites is northwesterly, when precipitation occurs, there is more likely to be transport from the east than the west. This is evident from both the 10-m tower meteorological data at nearby Longs Peak and from back trajectory analyses. April 2013 had unusually frequent transport from eastern Colorado, even compared to the April average. Other Aprils with higher than average Nitrogen deposition also tended to have higher than average transport from the east, while Aprils with lower average deposition had more transport from other areas, usually to the west and south. Some analyses were completed for both 2008-2015 when there are higher resolution meteorological data available and for 1980-2015 with a lower resolution, but longer time period. Results were consistent with both sets of trajectories.

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TECHNICAL SESSION 9:
NOVEL MEASUREMENTS OF ATMOSPHERIC DEPOSITION AND ECOSYSTEM PROCESSES

Session Chairs: Emily Elliott and John Walker,
University of Pittsburgh and U.S. EPA

Deposition and re-emission of ammonia by dew

Jeffrey Collett[1], Greg Wentworth[2], Jennifer Murphy[3], Katherine Benedict[4] and Evelyn Bangs[5]

Ammonia (NH_3) is a highly water soluble gas-phase pollutant yet its interaction with dew is poorly understood. Dew evaporation is one hypothesis used to rationalize a frequently observed but currently unexplained morning increase in NH_3 occurring between ~7:00-10:00 local time. In this study simultaneous quantification of dew composition, dew amount and NH_3 gas-phase concentrations was completed to address the following: 1) if dew is a significant reservoir for NH_3, 2) how much NH_4^+ in dew is released as NH_3 during evaporation, 3) whether or not dew evaporation can explain observed increases in morning NH_3. Measurements were carried out over a 90-day period in a remote high elevation grassland site in Colorado. Dew was collected off a Teflon sheet covering a horizontal styrofoam block. Dew amount was continuously monitored using a "dew meter" consisting of a tray with artificial turf resting atop an analytical balance. Atmospheric NH_3 was measured via cavity ringdown spectroscopy at a time resolution of 1 min.

Roughly two-thirds of boundary layer NH_3 was sequestered in dew overnight suggesting it is a significant reservoir. Dew composition and pH were used to estimate that, on average at this location, 94% of dew NH_4^+ is released to the atmosphere as NH_3 during evaporation. Coincident timing of dew evaporation and NH_3 increase, as well as calculated fluxes and approximate mass balance closure of NH_4^+ and NH_3 provide strong evidence that, at least at this site, dew evaporation is responsible for the morning increase in NH_3. Increases in NH_3 following light rain events suggest a need to also examine possible re-emission of NH_3 originally wet deposited as NH_4^+.

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Wet atmospheric deposition of organic carbon across Pennsylvania: rates and relation to inorganic elements of precipitation chemistry

Lidiia Iavorivska[1], Elizabeth Boyer[2] and Jeffrey Grimm[3]

Transfers of organic carbon (OC) from the atmosphere to land occur as wet deposition (via precipitation) and as dry deposition (via surface settling of particles and gases). Wet deposition is the major pathway for removal of OC from the atmosphere, affecting both atmospheric and landscape processes. OC deposited with precipitation to the landscape affects organic acidity, nutrient balances, and metal complexation. Since OC is highly chemically reactive and bioavailable it influences productivity in aquatic ecosystems. Compared to a large body of research on atmospheric deposition of acidic compounds and persistent organic pollutants, studies regarding the abundance of OC in precipitation are relatively sparse. One reason is that concentrations of OC in precipitation and their rates of atmospheric deposition are not routinely measured as a part of major deposition monitoring networks. Our synthesis of global data on concentrations and deposition rates of OC showed substantial inputs of OC in both urban and rural settings. Using aliquots from weekly samples collected through a National Atmospheric Deposition Program network of sites in Pennsylvania we quantified the inputs of OC to the landscape via atmospheric deposition across the state in order to assess their quantitative relevance for watershed nutrient budgets. The rates of OC wet deposition showed a pronounced seasonality and spatial distribution. Further, significant links between OC and inorganic constituents in precipitation, especially sulfate and inorganic nitrogen forms, suggest that they have similar sources and OC may affect their atmospheric transport and the ecological fate.

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Atmospheric Reactive Nitrogen in Northern Colorado

Katherine Benedict[1], Yixing Shao[2], Amy P. Sullivan[3], Yi Li[4], Evelyn Bangs[5], Bret A. Schichtel[6] and Jeffrey L. Collett Jr.[7]

Ammonia emissions in northeastern Colorado impact sensitive ecosystems in Rocky Mountain National Park (RMNP). The spatial distribution of ammonia in the region and specific transport pathways are uncertain. It is important to understand the degree to which these different urban and agricultural sources impact RMNP, and how various meteorological conditions are associated with high-deposition periods in the park. Ongoing measurements at RMNP include 24hr-integrated gaseous and particulate nitrogen species measured by denuder/filter pack methods, high-time resolution gaseous ammonia, and wet deposition of nitrogen compounds. Research in RMNP has been combined with measurements in the Front Range and eastern Plains of Colorado to better understand the movement of ammonia from source regions to the alpine ecosystems of RMNP. Here we present observations from high-time resolution ammonia instruments across an east-west transect as well as mobile observations that provide a snapshot of the spatial distribution of ammonia concentrations. Data presented will also include longer term passive samplers for ammonia which are used to examine the spatial variability of 2-week average concentrations across northern Colorado in the summer from 2010 to the present.

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Atmosphere-biosphere exchange of biogenic oxidized volatile organic compounds over a Southeastern United States forest

Tran Nguyen[1], John D. Crounse[2], Alexander P. Teng[3], Jason M. St. Clair[4], Fabien Paulot[5], Glenn M. Wolfe[6] and Paul O. Wennberg[7]

Biogenic volatile organic compounds (BVOC), such as isoprene, dominate the oxidant reactivity above forested regions of the world. During the 2013 Southern Oxidant and Atmosphere Study (SOAS), we measured the mixing ratios and atmosphere-biosphere exchange velocities for a variety of BVOC oxidation products in an Alabama forest, near the NADP Centreville Station, using a high temporal- and mass-resolution spectrometer equipped with a soft-ionization mechanism. The measured compounds include hydrogen peroxide (H_2O_2), nitric acid (HNO_3), hydrogen cyanide (HCN), hydroxymethyl hydroperoxide (HMHP), peroxyacetic acid (PAA), isoprene hydroperoxy aldehydes (HPALD), isoprene hydroxy nitrates (ISOPN), isoprene hydroxy hydroperoxide and epoxydiols (ISOPOOH + IEPOX), and other multifunctional species. We present eddy-covariance flux and deposition velocity observations for several ideal days where rapid uptake of oxidized carbon to the canopy was unambiguously observed. The results are discussed with respect to the resistance framework, where deposition was observed to clearly depend on the molecular properties of the atmospheric trace gases. The impact of this dataset on atmospheric modeling and regional ecosystems will be discussed.

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A comparison of AMoN measurements with localized, arrayed passive NH_3 samplers in Northern Utah

Randy Martin[1] and Munkh Baasandorj[2]

In 1983, the National Atmospheric Deposition Program (NADP) established a National Trends Network (NTN) monitoring location in Utah's Cache Valley (UT01) and the data have consistently shown wet deposition of ammonium (NH_4^+) among the highest in the nation. Several airsheds in the region have been promulgated as $PM_{2.5}$ non-attainment and the largest mass fraction of the local $PM_{2.5}$ is most often ammonium nitrate (NH_4NO_3). Denuder measurements at the Logan, UT regulatory site in 2003-04, found winter and summer NH_3 concentrations averaged 9.2 ± 2.3 and 3.7 ± 0.4 μg/m^3, respectively. In the winter and summer of 2006, an array of 25 passive samplers was deployed throughout the Cache Valley for three different sample periods during each season. The winter and summer valley-wide NH_3 concentrations averaged 28.1±5.1 and 22.9±5.2 μg/m^3, respectively. More recently, during January and February of 2016, a slightly smaller version of the passive array was repeated in the Cache Valley, parallel to a study along the Wasatch Front, wherein 10 samplers were deployed at many of the same locations as the 2006 study for seven periods. The spatial concentration contours from this study were found to be very similar to the previous study. However, the valley-wide average NH_3 concentrations were significantly greater with an overall average of 106 ± 22.7 μg/m^3. For comparison, the Wasatch Front NH_3 concentrations averaged 14.2 ± 2.0 μg/m^3.

The UT01 location was updated in 2011 to be a part of the NADP's Ammonia Monitoring Network (AMoN). At the same a site (UT97) was established in the Salt Lake valley. In support of the NTN measurements, the AMoN data consistently indicated that the Cache Valley location had among the highest gas-phase NH_3 measurements in the USA. UT01's annual average NH_3 concentrations for 2012, 2013, and 2014 were 15.0 ± 1.7, 18.7 ± 1.9, and 15.8 ± 2.3 μg/m^3, respectively. During the same time period, UT97's annual average concentrations were 4.0 ± 0.5, 3.9 ± 0.6, and 4.5 ± 0.4 μg/m^3, respectively.

It is of interest to note that the data from UT01 are often flagged with the QR code "B", meaning the data are valid but with minor problems. The site is located on a Utah State University research farm and small quantities of livestock are often within the given boundary. This presentation will examine the siting both UT01 and UT97 as to its representativeness of the given airsheds.

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Temporal variability of ammonia fluxes from open-path, eddy covariance measurements

Mark Zondlo[1], Da Pan[2], Katherine B. Benedict[3], Bret A. Schichtel[4] and Jeffrey L. Collett Jr.[5]

Ammonia (NH_3) is an important gas phase precursor species for aerosol formation and growth, and particle phase ammonium is a large part of aerosol molar composition. Ammonia emissions to the atmosphere have high spatiotemporal variabilities. Quantifying NH_3 fluxes are further complicated by severe measurement problems including efficient adsorption to instrument surfaces, low mole fractions (pptv-ppbv), and gas-particle phase partitioning. To these ends, we have developed an open-path, eddy covariance NH_3 instrument that minimizes many of these sampling problems. A quantum cascade laser probes the fundamental absorption band of NH_3 for high sensitivity and is tuned to an absorption feature of NH_3 that retains the sensitivity while minimizing spectral interferences from other trace gas absorbers (e.g. CO_2, H_2O). The open-path configuration avoids the sampling artifacts associated with closed-path systems and thereby allows for fast response flux determination. Calibrations with gas standards and permeation tubes were conducted in the laboratory using direct absorption spectroscopy, and intercomparisons with commercial instruments were conducted in the field at moderate and high concentrations (> ppbv). The instrument precision is 150 pptv (10 Hz), and cross covariance analyses between vertical wind and NH_3 indicate a minimal detectable flux of ~1 ng NH_3/m^2/s at 10 Hz. Cospectral analyses with other scalars such as temperature, moisture, methane, and carbon dioxide indicate the system has a comparable performance as other eddy covariance sensors. Measurement accuracy is ±(15% + 0.3 ppbv) with the zero point drift dominating the uncertainty in the field. Eddy covariance measurements for a three week period in summer 2015 in Rocky Mountain National Park, Colorado, showed the capabilities of the system to measure fluxes in both clean and moderately polluted conditions. Net deposition of 3.2 ng N/m^2/s occurred during upslope events from the transport of air from the agricultural/urban areas on the plains. In contrast, during downslope events when clean, free tropospheric air flowed across at the site, re-emission of NH_3 to the atmosphere of a similar magnitude was observed. The system is being re-deployed at RMNP for the summer 2016 at the same site. Ongoing efforts to improve the zero point drift at sub-ppbv levels and variations in NH_3 fluxes through the summer will be discussed.

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Measurements of NOy and HNO_3 at a Rural-Forested Site in the Southern Appalachians

Eric Edgerton[1], John Walker[2], Xi Chen[3] and John Jansen[4]

Nitrogen oxides (NOy) and nitric acid in particular (HNO_3) can be important contributors to nitrogen loadings in terrestrial and aquatic environments. This presentation will describe one year of continuous, ground level measurements of NOy and HNO_3 at the Coweeta Hydrological Laboratory in rural southwestern North Carolina. The site is located at an elevation of approximately 685 m (amsl) in an area of complex terrain, with nearby ridgetops approaching 1000 m within 1 km to the north, west and south. Elevation decreases to the east in the direction of local highways and population centers. NOy was measured via reduction to NO on hot (350 C) molybdenum with detection via O_3-NO chemiluminescence. HNO_3 was measured inn parallel by removing it from the airstream with a KCl-impregnated annular denuder and calculating the difference between undenuded and denuded NOy values. We will also present and compare HNO_3 data from the summer of 2015 and spring of 2016 that was collected with a MARGA system located on a nearby flux tower and with an inlet height of 44 m agl.

Results of ground-level measurements show that 12-month average concentrations of NOy and HNO_3 are relatively low (1.04 ppb and 0.16 ppb, respectively) and exhibit interesting temporal patterns. Mean NOy concentrations are highest in first quarter (1.47 ppb) and lowest in third quarter (0.61 ppb), while HNO_3concentrations are highest in first and second quarters (0.20 ppb) and lowest in fourth quarter (0.09 ppb). Hourly data for NOy consistently show minimum values in the early morning, maximum values midday and a rapid decline through the evening hours. This pattern differs markedly from that observed at sites in flat or rolling terrain which typically show overnight maxima and midday minima. During first quarter, the diurnally averaged minimum and maximum are 1.14 ppb and 1.77 ppb, respectively. During third quarter early morning concentrations are much lower (sometimes below 0.1 ppb) and diurnally averages minimum and maximum are 0.24 ppb and 1.20 ppb, respectively. HNO3 concentrations exhibit a more familiar "photochemical" pattern, with minimum concentrations in the early morning (<0.05-0.1 ppb) and peak concentrations between 1200 and 1500 LST (0.2-0.4 ppb).

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TECHNICAL SESSION 10:
INFLUENCES OF TRENDS AND CLIMATE CHANGE ON CRITICAL LOADS

Session Chairs: Jason Lynch and Tamara Blett,
U.S. EPA and National Park Service

Reactive nitrogen emissions from Marcellus Shale natural gas extraction

Emily Elliott[1] and Justin G. Coughlin[2]

Unconventional extraction of natural gas has been increasingly examined as a source of methane, a potent greenhouse gas. However, unconventional shale gas extraction is also an energy- and water-intensive process that can generate significant emissions of reactive nitrogen (N), mainly nitrogen oxides ($NO = NO + NO_2$) and ammonia (NH_3). In this study, we examine through modeling and rare empirical observations from a research wellpad, the influence of shale gas extraction on regional and local air quality, respectively and the potential impact of these emissions to critical loads of atmospheric N deposition.

The Marcellus Shale is Devonian rock formation found in Maryland, New York, Ohio, Pennsylvania, and West Virginia that is producing roughly 430,000 $m^3$of natural gas per day (U.S. EIA, 2016). NO_x and NH_3 emissions can originate from wellpad development, vehicular traffic to the wellpad site, and large diesel generators used to power drilling rigs, pumps, and compressor stations. Existing studies on reactive N emissions from Marcellus employ either: 1) literature-based emission factors to model NO_x emissions or 2) measure relative changes in ambient air concentrations in areas of shale gas extraction. Here in this study, we use natural stable isotope tracers associated with fossil fuel combustion to examine the fluxes and relative extent of NO_2 and NH_3 emissions across a wellpad and road transect. Using a spatially explicit model, we assess the potential impact of Marcellus shale NO_x emissions to regions of Pennsylvania recovering from historically high rates of atmospheric deposition.

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Modeling the long-term deposition trends in US over 1990—2010 and their impacts on the ecosystem assessment

Yuqiang Zhang[1], Rohit Mathur[2], Jesse Bash[3] and Shawn Roselle[4]

Reactive nitrogen (Nr) is very important pollutant which at the same time plays a very important role on air and water quality, human health and biological diversity. The atmospheric nitrogen deposition can cause acidification and excess eutrophication, which brings damages to the ecosystems. Quantifying the total deposition is US is still a challenge due to the lack of the long-term observation data for the dry deposition.

For this study, we use a comprehensive coupled meteorology-air quality model (WRF-CMAQ) to simulate deposition changes in US over 1990—2010. The WRF-CMAQ model was run for the continental US using a 36km by 36km horizontal grid spacing, by using a consistent emission inventory recently developed by Jia et al., (2013). We found significant decreasing trend for the total inorganic nitrogen over the East and West coast of California, and increasing trend in the East North Central. The decreased total deposition was controlled by the oxidized nitrogen, as a result of the recent consistent NOx emission reductions due to air regulations such as the Clean Air Act and the NOx State Implementation Plan, consistent with other studies (Li et al., 2016; Schwede and Lear, 2014). The increased inorganic nitrogen deposition was dominated by the reduced nitrogen, which was attributed to the unregulated increasing ammonia (NH_3) emissions. The dry and wet inorganic nitrogen deposition trends also have a different spatial patterns: wet deposition was decreasing all over the U.S., while the dry deposition decreased over the East and increased over the Central areas, which was controlled by the increased dry NH_3 deposition. The contribution of the reduced nitrogen to the total nitrogen varies both spatially and temporally: it is usually above 50% in the North Central areas, and below 50% in the East and West of U.S. However we see a significant increasing trend for these contributions all over the U.S. as a result of the NOx emission reductions and ammonia emission increases.

Future effort will be investigated to compare the WRF-CMAQ model results with the estimated total deposition by using the hybrid approach developed by Schwede and Lear (2014). Then we will also quantify the ecosystem effects from the nitrogen deposition changes for the past 20 years on the critical loads and biodiversity.

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Sulfur, nitrogen, and climate change biogeochemical and empirical effects modeling in the eastern United States: what are we doing and why might anybody care?

T.J. Sullivan[1] and T.C. McDonnell[2]

Recent research has focused attention on the responses of aquatic and terrestrial resources in the eastern United States to decreasing levels of atmospheric nitrogen (N) and sulfur (S) deposition in the context of a changing climate. Both empirical and coupled biogeochemical and ecological response models have proven useful in highlighting uncertainties in data availability and scientific understanding of the major processes that govern chemical and biological responses. Research undertaken recently by our project team is highlighted here, including 1) empirical analysis of the influence of climate on the long-term recovery of Adirondack Mountain lake chemistry from prior high levels of atmospheric S and N deposition; 2) interactions between stream acidification (top-down stressor) and stream warming (bottom-up stressor) as controls on the suitability of stream habitats for cool water species in the southern Appalachian Mountain region; and 3) biogeochemical and terrestrial plant biodiversity modeling at three sites in New Hampshire, Virginia, and Tennessee, using the coupled model chains ForSAFE-Veg and VSD+PROPS. Results of model projections and some of their uncertainties are discussed.

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Recent advances for critical loads of herbaceous species and influences of climate change

Christopher Clark[1] and Samuel Simkin[2]

Nitrogen deposition is known to be a major stressor to herbaceous species across most industrialized areas owing to the potential for both acidification and eutrophication to influence community dynamics. Previous work (Simkin et al. PNAS 2016) quantified the critical loads for changes in total herbaceous species richness across the contiguous U.S., using data from over 15,000 plots nationwide. Here we expand that research to examine which species are positively, negatively, and unaffected by N deposition to disentangle which species are responsible for the aggregate patterns reported earlier. We found that across the 188 species with adequate data and robust statistical results, there were many species relationships with N deposition, including increasers (11%), decreasers (13%), non-responders (21%), and hump-shaped responders (55%). Critical loads varied widely across species, from <2 kg N ha^{-1} yr^{-1} to almost 18 kg N ha^{-1} yr^{-1}). When examined geographically across the country, it was clear that there were "winners and losers" co-occurring almost everywhere in the country, with the highest numbers of losers in the upper Midwest and parts of the east. This work will help identify areas and species of particular concern from impacts due to N deposition, and help inform policy decisions on national air quality under the NAAQS.

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Assessing regional impacts of N deposition on forests through species specific responses

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Forest growth is widely thought to be nitrogen (N) limited. However, additional N through N deposition or fertilization does not consistently produce increased tree growth and can even contribute to reduced tree growth and loss of species diversity. We recently characterized continuous growth and survival responses of 89 tree species to N deposition for the conterminous United States (US) for which responses were increasing, decreasing, increasing then decreasing, or flat across the range of N deposition exposure. Applied across the US, these species-specific responses indicate that almost every forested region has tree species that are declining in growth or survival as N deposition increases. These species-specific relationships between nitrogen deposition and tree demographic rates can be applied to specific ecosystem management units using current and local forest species compositions, climates, and N deposition rates to estimate the net and species specific effects of N deposition on tree growth and survival. Such a tool can be used to identify specific forests systems that are or could be at risk, and facilitating management decisions in targeting tree species and their linked ecosystem services to ameliorate the effects of N deposition. Additionally, the species-specific response curves enable policy makers to set critical loads objectively for specific forest characteristics.

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TECHNICAL SESSION 11:
URBAN ATMOSPHERIC CHEMISTRY AND DEPOSITION

Session Chairs: Tom Whitlow
Cornell University

Sulfur and nitrogen compounds in wet atmospheric deposition and in ambient air as indicators of emissions reduction strategies at Mexico City

Humberto Bravo A.[1], Rodolfo Sosa E.[2], Ana Luisa Alarcón J.[3], Maria del Carmen Torres B.[4], Monica Jaimes P.[5], Armando Retama H.[6], Pablo Sánchez A.[7]and Elías Granados H.[8]

The Mexico City Metropolitan Zone (MCMZ) is accepted as having critical levels of air pollution. In the 1980s, particulates and sulfur dioxide (SO_2) were identified as the main atmospheric pollutants and an effort to reduce emissions in the MCMZ was made by replacing fuel oil with natural gas in power plants located inside. This resulted in the reduction in the levels of both pollutants. Actually SO_2 levels do not exceed its ambient air quality standard; however acid rain is a significant issue. In this study, spatial and temporal variations in the chemical composition of rain in Mexico City between 2003 and 2014 were analyzed; sulfate and nitrate ions and pH were obtained weekly at 16 sampling stations located in the MCMZ. Furthermore, sulfur dioxide (SO_2) and nitrogen oxides (NOx) were evaluated from 1990 to 2014 at the MCMZ air quality monitoring network. In order to obtain the magnitude in the emissions reduction of sulfur compounds relative to nitrogen compounds, SO_2/NOx were obtained for ambient air, as well as SO_4^{2-} /NO_3^- in wet atmospheric deposition.

In 2003 a difference among the sampling sites was observed in the SO_4^{2-} to NO_3^- equivalents ratio, sites located in the north presented a higher ratio of 2, while the sites located in the south the value was 1. In 2014, a homogeneous distribution was observed, the ratio was the same in all the Mexico City sampling sites: 1.5 (μeq/L SO_4^{2-} to μeq/L NO_3^-). The pH values of the samples at the stations located in the south were more acidic than the samples for the stations in the north. This result is in line with meteorological conditions, prevailing winds blowing from the north to the south, as well as emission sources located in the north sector. SO_2 levels have decreased from 1990 to 2014 by about 90%, while those of NOx by 20%. The SO_2 / NOx ratio has declined about 60% indicating more effective strategies in reducing SO_2 (change of fuel or sulfur reduction) than for NOx emissions. This, because the NOx emission sources are diverse and also NOx are part of complex mechanisms of atmospheric deposition and photochemistry.

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Variation and drivers of nitrogen deposition, cycling, and loss throughout an urban metropolitan area

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As the world's urban areas continue to grow in both population and extent, it is essential to understand patterns and drivers of atmospheric nitrogen (N) deposition in these areas. Urban N deposition may have substantial effects on regional N budgets, and geographic areas downwind of urban areas may be directly affected by N deposition in cities. Though urban N deposition has been shown to be elevated in numerous studies around the world, past research has typically examined only one urban sampling location either in a binary urban-rural comparison or as the anchor for an urban-rural spatial gradient. During the growing seasons of 2014 and 2015, we measured throughfall deposition, N leaching, and soil respiration at 24 sites around the greater Boston area. In addition, we established two new urban NADP National Trends Network (NTN) sites established in 2015 and 2016 in the City of Boston. We find that rates of atmospheric N deposition are on average 8.70 ± 0.68 kg N ha^{-1} yr^{-1}, but vary more than threefold, from 3.84 to 13.82 kg N ha^{-1} yr^{-1} within the greater Boston area. The mean deposition rate is almost double the rate of total (wet + dry) N deposition measured at the rural NADP-CASTNET site in Abington, CT, ~90 km southwest of Boston. Ammonium (NH_4^+) deposition in the greater Boston area makes up about 70% of total N deposition and is highest in late spring. Rates of NH_4^+ and total inorganic N deposition are strongly correlated with on-road emissions of nitrogen oxides (NO_x) and distance to roads, suggesting a significant source of ammonia (NH_3) emissions from urban vehicles. In contrast to past studies, we do not find significant relationships between atmospheric N inputs and N losses via leaching within the city, nor do we find a relationship between atmospheric N deposition and soil carbon dioxide (CO_2) respiration. The results of our work demonstrate that N deposition can be both high and variable within an urban area and highlight the need for more measurements of atmospheric N deposition across urban areas.

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Distribution of atmospheric reactive nitrogen in Indo-Gangetic Plains (India)

Saumya Singh[1], Anshu Sharma[2] and Prof. U.C. Kulshrestha[3]

In India, most of the human population lives in rural areas. People depends on agriculture products to meet the demand of food supply. In order to get higher yield of agriculture and food product, increased practice of fertilizer application has added extra burden of nutrients especially, the reactive nitrogen (Nr) species viz NH_3 and NO_x. Growing energy demands has resulted in increased emissions of NOx from coal combustion in thermal power plant and the petroleum combustion in transport sector. In addition, biomass burning in traditional cooking and heating has become significant source of NH_3 and NO_x in Indian region.

Significance of the study lies in the fact that increasing Nr emissions have adverse impact on human health, plant, soil and water bodies directly and to see the effect, knowledge of emission and deposition for Nr at different sites. Hence, the selection of the sites for present study was done very carefully. Indo-Gangetic plains, which is most productive, fertile and most populated region of India were selected to study the reactive nitrogen deposition. It has two extreme kind of sites like Delhi, a typical urban site and on other hand a village with agricultural activities as rural site.

Atmospheric abundance of major inorganic (Nr) species in gaseous phase i.e NH_3 and NO_2 and in particulate phase (NH_4^+ and NO_3^-) has been measured for one year, on monthly basis. Study, presents spatial and temporal variation of major reactive nitrogen species at representative sites of most populated and fertile part from India. During the presentation, a brief scenario of Nr deposition research in India, will also be discussed in details at the conference.

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Atmospheric deposition of nitrogen in New York City and Boston

Thomas Whitlow[1], Yoshiki Harada[2], Pamela Templer[3] and Lucy Hutyra[4]

Nitrogen emissions from electrical power plants, automobile exhaust and fertilizer applications are the major sources of nitrogen deposition in rain and snow onto ecosystems of the northeastern United States. Small amounts of nitrogen deposition can serve as fertilizer and stimulate growth of plants. However, high rates of nitrogen deposition can lead to a series of negative consequences, including reductions in plant diversity, acidification of soils and waterways, and harmful effects on human health. The Clean Air Act Amendments in 1990 led to declining rates of nitrogen deposition in the northeastern U.S., but rates remain significantly elevated (more than 10X pre-industrial levels) and they occur as hot spots in urban areas.

We established two urban monitoring programs of atmospheric deposition in 2015, with one in Boston, MA and the other in New York City. We found that rates of atmospheric deposition are higher near the ground than on rooftops at the Brooklyn Grange in NYC. This difference makes intuitive sense in cities, where vehicles emit a variety of heavy metals and NOx from mechanical wear and fuel combustion. We also found that deposition and downspout drainage are relatively low, but leachate directly beneath the planting beds is very high. This pattern suggests that denitrification is occurring in the drainage zone between the beds and the roof drains. Further experiments using Br and nitrate pulses and underway to determine whether N is disproportionately leaving the system. We also established two new urban sites in the National Atmospheric Deposition Program in Boston, MA, with one site at Boston University and one at the Arnold Arboretum of Harvard University. Data from these urban sites provide a more complete understanding of the nitrogen fluxes in precipitation around the greater Boston and New York City areas and will contribute to our understanding of nitrogen pollution around the United States. Ultimately, our work will create a better understanding of how atmospheric nitrogen pollution affects nitrogen inputs to our terrestrial ecosystems and nearby waterways, providing policy-relevant data with implications for both ecosystem and human health.

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POSTER SESSIONS

IN ALPHABETICAL ORDER BY AUTHOR

Establishing a National Aeroallergen Monitoring Network: Opportunities for NADP Collaboration

Norman Anderson[1], Andy Johnson[2], Christopher Lehmann[3], Arie Manangan[4], Wendy Brunner[5], Jessica Wurster[6] and Leonard Bielory, MD[7]

This presentation describes an opportunity for National Atmospheric Deposition Program (NADP) collaboration in the formation of a national aeroallergen monitoring network. Airborne pollen and mold spores (collectively, aeroallergens) are of keen concern due to their adverse effect on people with asthma and allergies. The impact of aeroallergens is expected to increase due to climate change and other environmental factors. The Centers for Disease Control and Prevention (CDC) has established a partnership with the Council of State and Territorial Epidemiologists (CSTE) through CSTE's Asthma and Allergy Workgroup. This workgroup supports the monitoring, modeling, and research efforts focused on human exposure to aeroallergens in the United States.

CSTE held its first pollen summit in 2015, which concluded with the need to establish a nation-wide data pollen repository to include both traditional and novel pollen measures and to track information for public health actions. Identified needs included more research on pollen forecasting, the development of human health alerts, and a support platform for research. There are 85 existing ambient monitoring sites coordinated through the National Allergen Bureau (NAB). Yet, they lack sufficient temporal and spatial resolution to fully represent affected populations. Also, data access is limited to cumbersome one on one agreements with the individual monitoring stations. This is why CSTE is developing a comprehensive strategy to establish a national aeroallergen monitoring network, possibly following an NADP-like model of multiple stakeholder agencies under a shared decision-making governance structure.

The network will build upon the existing NAB sites, as NAB provides consistent and high quality data through its training and certification processes. In addition, it is evaluating alternative approaches to assess aeroallergen exposure. These alternative approaches include working with the NADP, the National Phenology Network (NPN), as well as exploring remote sensing and climate data, automated collection stations, and low cost sensors. Outreach plans also include coordination with the Department of Agriculture's crop and forest information and with the local/state/federal ambient air quality monitoring networks.

The network plan also includes optimizing pollen data use for the public benefit: epidemiological and climatological research; short-term forecasting; modeling and future-casting; health risk management; and ensuring long term sustainability through engagement of public health stakeholders. CSTE's goal is a network that is sufficient to address this currently under-recognized and under-resourced public health problem. We provide an overview of CSTE's plan for a national monitoring network and opportunities to collaborate in the early stages of this environmental health initiative.

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Nitrogen from the Atmosphere: A summary of the pathways of reactive nitrogen in the environment and NADP's role in better understanding this essential element

Tom Butler[1], Gregory Beachley[2], Pamela Padgett[3] and Cari Furiness[4]

Nitrogen is an essential element to all life and cascades through biogeochemical cycles as reactive nitrogen (Nr) in many different chemical forms. The atmosphere is an important reservoir of Nr, where significant photochemical reactions and partitioning from gaseous to particulate and dissolved phases takes place. The chemical form of Nr dictates the form and degree to which Nr is deposited to the landscape, or re-emitted to the atmosphere. The exchange of Nr between the atmosphere and the surface is important, given the role of excess Nr as an environmental pollutant.

NADP has played an integral role in better understanding atmospheric cycling of Nr and in the exchange between the atmosphere and earth's surface, including biosphere, lithosphere, and hydrosphere.

Here we present highlights from an updated NADP nitrogen brochure entitled *Nitrogen from the Atmosphere*, which updates and replaces the former publication, *Nitrogen in Rain*, which was originally developed ~2000. The brochure is designed for a general audience in order to better communicate the issues related to atmospheric Nr, its measurement, and impact on the environment.

Some important points presented in this brochure include:

- The many forms of Nr and their sources
- The relative importance of atmospheric emissions of NO_x and NH_3 which contribute to Nr in the landscape
- Effects of nitrogen on forests, freshwaters and estuarine systems, and a case study of how nitrogen impacts Chesapeake Bay, as well as mitigation efforts to reduce negative impacts.
- Critical loads for nitrogen as a policy tool to reduce negative impacts of nitrogen deposition
- Measurement of Nr deposition by NADP and CASTNET to better quantify trends and rates of N deposition by various species (e.g. wet and dry NO_3^- and NH_4^+, NH_3)
- The role of agriculture in managing nitrogen inputs
- Quantification of total atmospheric N deposition using both measured and modeled estimates for the USA

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Organic functional group and OM/OC measurements at select IMPROVE sites using Infrared Spectra: Organosulfates and amines

Ann Dillner[1], Mohammed Kamruzzaman[2] and Satoshi Takahama[3]

The Interagency Monitoring of Protected Visual Environments (IMPROVE) is a speciation particulate matter monitoring network in the U.S. located primarily in Class 1 visibility areas. Organic carbon (OC) is measured using thermal optical reflectance (TOR) on quartz filter samples and an organic matter (OM) to OC ratio (OM/OC) of 1.8 is assumed to account for the hetero-atoms attached to the carbon including oxygen, hydrogen, sulfur and nitrogen. In previous work, we developed a method using Fourier transform-infrared spectroscopy (FT-IR) and partial least squares (PLS) regression to measure the four largest organic functional groups, aliphatic C-H, alcohol/sugar OH, carbonyl and carboxylic acid OH. These functional groups are summed to estimate OM and the carbon from the functional groups is summed to estimate OC. With this method, OM/OC can be estimates for each sample rather than relying on one assumed value for all samples. More recently, we have adopted a range of strategies for PLS model development to better estimate OC from functional group measurements (as evaluated by comparison to TOR OC).

We have expanded our suite of functional groups to include organosulfates and amines. Amines are ubiquitous in the atmosphere and come from car exhaust, animal husbandry, biomass burning and vegetation among other sources. We developed a calibration for the amine functional group and applied it to samples collected throughout 2013 at 17 IMPROVE sites. Urban sites showed the highest amine concentrations due to traffic and Fresno, CA an urban site surrounded by cattle and other agriculture, had the highest amine concentration of any site due to traffic and animal husbandry. The lowest amine concentrations were found at rural sites that did not experience prescribed or forest fires in 2013. Samples collected during the Rim Fire near Yosemite National Park had the highest individual amine concentrations of all the samples. Rural sites in the Southeast and Kansas that have prescribed fires during the January to March and high biogenic emissions in the summer, had higher amine concentrations than other rural sites. The OM/OC is higher when the amine functional group is included but for most samples, the increase is small.

Organosulfates are tracers for secondary organic aerosol (SOA) in regions with high sulfate. Results from the same 17 IMPROVE sites and the impact on OM/OC will be discussed.

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Estimating sources, sinks and fluxes of atmospheric reactive nitrogen within a forest canopy

Tomer Duman[1], John T. Walker[2], Jesse O. Bash[3], Cheng-Wei Huang[4], Khaled Ghannam[5] and Gabriel G. Katul[6]

Canopy-scale flux measurements and inferential models are useful for developing estimates of net emission or deposition of trace gases and aerosols above forests. However, more detailed measurements and models are needed to relate net fluxes to biological, physical, and chemical processes occurring within the air-canopy-soil system. These processes occur over multiple time scales making direct measurements of sources or sinks difficult to conduct. However, measured concentration profiles can be used to infer the effective source-sink distribution if the flow field is known – commonly referred to as the solution of the inverse problem. In-canopy and above-canopy multi-level concentration measurements of reactive nitrogen compounds (ammonia, nitric acid, nitrous acid), as well as other reactive gases that influence ammonia gas-to-particle partitioning (hydrochloric acid) and surface acidity (sulfur dioxide), are presented within a deciduous second-growth 180 year old oak-hickory forest situated within the Southeastern U.S. Three different approaches are used to solve for the source-sink distribution from the measured mean scalar concentration profiles: (1) a Eulerian high-order closure model that solves the scalar flux budget equation, (2) a Lagrangian localized near-field (LNF) method and (3) a new full Lagrangian stochastic model that estimates the dispersion matrix. As each of these methods is subject to different assumptions, the combination and comparison of the three can be used to constrain the solution to the inverse problem and permit inference on the origin and fate of reactive compounds within forested canopies.

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Mercury in Fishes from Yosemite (CA), Mount Rainier (WA), and Rocky Mountain (CO) National Parks: Potential Drivers and Ecological Risk

Colleen Flanagan Pritz[1], Collin Eagles-Smith[2], James Willacker[3], Michelle Lutz[4] and Michael Tate[5]

The National Park Service (NPS) safeguards over 400 special places for the protection of unique natural resources and scenic beauty. Although celebrated as some of the most pristine ecosystems, recent studies have documented the presence of mercury in fish from NPS units across the western United States, including Mount Rainier (MORA; WA), Rocky Mountain (ROMO; CO), and Yosemite (YOSE; CA) national parks. Even protected areas, such as national parks, are subjected to mercury contamination because it is delivered through atmospheric deposition, often after long-range transport. Approximately 1,200 fish (primarily Salmonidae) were sampled from 52 subalpine lakes and rivers between 2003–2012 in MORA, ROMO, and YOSE, and analyzed for total mercury concentrations. Preliminary results indicate that mercury concentrations in fish varied substantially among and within parks, suggesting that landscape factors may be particularly important determinants of mercury risk in the parks. Basin delineations and landscape models were utilized to determine significant drivers in fish mercury concentrations, such as atmospheric deposition and dissolved organic carbon (DOC). Although mercury concentrations in most fish were low, at some sites they exceeded health thresholds for potential impacts to fish, birds, wildlife, and humans. Ongoing studies aim to further characterize mercury in fish from eastern national parks, evaluate the utility of dragonfly larvae as a biosentinel for mercury in aquatic food webs, and assess mercury source attribution via mercury stable isotope markers. With a strong foundation in research, the NPS strives to understand how best to minimize air pollutants in park ecosystems, including airborne contaminants like mercury where concentrations in fish challenge the very mission of the national parks to leave resources and wildlife unimpaired for future generations.

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Meteorological Factors in Spring Dust Trends in the Southwestern U.S.

Kristi Gebhart[1], Jenny L. Hand[2], Warren H. White[3], Nicole P. Hyslop[4], Bret A. Schichtel[5] and Thomas E. Gill[6]

It has recently been observed that fine soil (<2.5 µm diameter) concentrations in the Interagency Monitoring of PROtected Visual Environments (IMPROVE) network in the southwestern United States have increased during March, while remaining relatively stable during other months. Fine soil concentrations at these mostly rural and remote sites typically peak in spring and early summer, so the March increase is interpreted as an earlier onset of the dust season. The rate of increase has been approximately 5% per year over 1995-2014 and is consistent with an approximately two weeks earlier beginning of the season. The March increase in fine soil is ubiquitous over a large four-state region and so is unlikely to be due to local sources or small scale meteorological fluctuations. There are implications for ecosystems, human health, the hydrologic cycle and visibility.

The temporal trends in March fine soil concentrations are correlated with the Pacific Decadal Oscillation (PDO) which, like the more familiar El Niño and La Niña, is related to sea surface temperatures in the Pacific Ocean, though with a longer periodicity. The PDO is believed to influence the position of storm tracks around the world. To further investigate how the PDO relates to meteorology and ultimately fine soil concentrations, hourly Automated Surface Observing System (ASOS) and Remote Automated Weather Station (RAWS) meteorological data were examined for the southwestern U.S. and back trajectories were generated for IMPROVE sites in Colorado, Utah, Arizona, and New Mexico for 1995-2014. The surface based meteorological data were examined for trends in wind speed, wind direction, temperature, precipitation, and humidity. The back trajectory endpoints, which track transport patterns, were grouped by the dust source regions that they traversed and then meteorology associated with endpoints in each source region were examined for number of endpoints (indicating transport direction), wind speed, temperature, precipitation, humidity, solar radiation, mixing depth, and transport height. The most significant findings are that during the second half of March, in the later years the transport patterns shifted so that IMPROVE sites in the Four Corners states received more air masses from the Sonoran and Mohave Deserts, the Colorado River Basin, and the San Joaquin Valley. Later years were drier than the earlier years as indicated by both lower average relative humidity and lower amounts of and less frequent precipitation. Wind speeds were somewhat higher.

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Celebrating lichens and their uses

Linda Geiser[1], Emily Underwood[2] and Stephen Sharnoff[3]

This illustrated poster demonstrates the air-pollution sensitivity of lichens and their value to humans, wildlife, and forests. Because lichens are often unfamiliar to policy and decision-makers tasked to protect or improve air quality, our goal is to 'put a face' on lichens and their roles—and to illustrate various species and their association with wildlife and ecological services that we as humans value. We hope to add dimension to the rationale for protecting species that may require cleaner air than that which directly protects human health. At the same time, we hope that our audience will discover in the poster illustration, text, and photographs something new to appreciate of the beauty, complexity, and vulnerability of lichens and their associated wildlife and ecosystems, or be intrigued by their remarkable pharmaceutical properties, environmental monitoring uses, and traditional uses.

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A National Assessment of the Ecological Effects of Nitrogen and Sulfur Oxides

Tara Greaver[1], Meredith Lassiter[2], Jeff Herrick[3], Joe Pinto[4], Alan Talhelm[5], Emmi Felker-Quinn[6], Ginger Tennant[7] and Randy Waite[8]

The current secondary National Ambient Air Quality Standards (NAAQS) for Oxides of Nitrogen and Sulfur (NOx and SOx) review started in the Fall of 2013. The scope of the review includes the atmospheric chemistry and ecological effects of nitrogen and sulfur deposition, in addition to NOx and SOx direct effects on US ecosystems. The Integrated Science Assessment (ISA) for NOx and SOx-Ecological Criteria is the scientific foundation for the review of the secondary NAAQS for NOx and SOx. The key ecological effects that occur under current levels of air pollution are ecosystem acidification (due to NOx, NHx and SOx), nitrogen enrichment/eutrophication (due to NOx and reduced nitrogen-NHx) and sulfur enrichment. The ISA for the current review is scheduled for release in 2016 and will include over 1000 new publications published since the 2008 ISA. The majority of new publications since 2008 (~400) are on the effects of N deposition/addition on terrestrial ecosystems, with over 130 papers each on freshwater acidification and freshwater eutrophication. In general, since 2008, there are a number of new studies on biogeochemical and physiological mechanisms, more syntheses such as meta-analyses, more regional scale evaluations and critical loads. This presentation will highlight progress and next steps in the ISA development.

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The Central Analytical Laboratory of the National Atmospheric Deposition Program: Thirty-Nine Years of Analytical Evolution

Lee Green[1], Katie Blaydes[2] and Angela Weddle[3]

This poster describes the evolution of analytical instrumentation used to measure acid rain constituents, at the National Atmospheric Deposition Program's (NADP) Central Analytical Laboratory (CAL). The poster also highlights significant milestones that the CAL has achieved in the last thirty-nine years.

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Cloud Water and Filter Pack Concentrations from the Summit of Whiteface Mountain, NY

Selma Isil[1] and Paul Casson[2]

The Clean Air Status and Trends Network (CASTNET) began operation in 1991, as an expansion of the National Dry Deposition Network, and was established in response to the 1990 Clean Air Act Amendments (CAAA). CASTNET's principal function is to provide air pollutant concentration data to evaluate the effectiveness of national and regional emission control programs. The program was designed to determine trends in rural atmospheric ozone, nitrogen and sulfur concentrations and deposition fluxes of nitrogen and sulfur pollutants. CASTNET is sponsored mainly by the U.S Environmental Protection Agency (EPA) and the National Park Service (NPS).

The Mountain Acid Deposition Program (MADPRO) was initiated in 1993 as part of the research necessary to support CASTNET's objectives. MADPRO focused on developing cloud water measurement systems to be used in a network monitoring environment and to update the cloud water concentration and deposition data collected during the Mountain Cloud Chemistry Program (MCCP). Measurements were conducted from 1994 through 1999 during the warm season (May through October) at three mountaintop sampling stations, one of which is located at Whiteface Mountain, NY. In 2001, the Adirondack Lakes Survey Corporation (ALSC), with support from the Department of Environmental Conservation (DEC) took over the field and laboratory operations at this site. Of the three original MADPRO sites, the Whiteface Mountain site is the only site that is still operational.

This poster will present results from CASTNET site WFM007 and the ALSC cloud water site WFM300 as well as trace gas measurements. Both sites are located on the Atmospheric Sciences Research Center's Summit Observatory which is located on the peak of the mountain at an elevation of 1483 m. CASTNET operates another site, WFM105, at the Marble Mountain Lodge site located on the eastern shoulder of the Whiteface massif at an elevation of 604 m. This site also houses a National Atmospheric Deposition Program/National Trends Network (NADP/NTN) site, NY98, for collection and analysis of weekly precipitation samples. Data from WFM105 and NY98 will also be presented and, where possible, compared with concentrations from the summit sites.

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Atmospheric Mercury Deposition at Selected NADP Sites

Miranda Jackson[1], Emmanuel Oleka[2], Godfrey Uzochukwu[3], Karen Skubal[4] and Dennis Jackson[5]

National Atmospheric Deposition Program Sites measure mercury, base cations, acids, and nutients in precipitation samples. The focus of this preliminary investigation is on atmospheric mecury deposition at selected NADP sites at North Carolina A&T State University, (NC17); Lake Waccamaw State Park, (NC08); Savannah River Site, (SC03) and Congaree National State Park, (SC19). Site characteristics are as follows:

NC17: University Farm located near industrial and manufacturing operations
NC08: located near Lake Waccamaw
SC03: located near nuclear materials
SC19: located near old bottomland hardwoods

Total mercury (Hg) wet-deposition recorded at the same date and month at selected sites were compared to determine which site has the lowest and highest mercury wet-deposition. Precipitation samples were collected from each site every Tuesday of the week and sent to Mercury Analytical Laboratory for analysis. Results were uploaded to NADP data repository for public access. The lowest Hg wet-deposition was recorded in the month of January 2015 and ranges from 38.19 ng/m2 at SC 19 to 52.58ng/m2 at NC 08. The highest Hg wet-deposition was recorded in the month of April 2015 and ranges from 228.96 ng/m2 at NC 08 to 454.06 ng/m2 at NC 17. The variation in Hg wet-deposition appears to be seasonal. Data suggests that mercury deposition increases as the weather becomes warmer. This study adds to national scale measurements of atmospheric Hg deposition amounts, geographic distribution, and trends across Southeast United States and improves environmental quality.

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Changes in Air Temperature and Precipitation Chemistry Linked to Water Temperature and Acidity Trends in Freshwater Lakes of Cape Cod National Seashore (Massachusetts, USA)

Krista Lee[1], Stephen M. Smith[2] and Sophia E. Fox[3]

Freshwater lakes are an important natural and cultural resource in national parks across the USA. At Cape Cod National Seashore, in southeastern Massachusetts, the water quality of these water bodies (known as kettle ponds), along with local precipitation chemistry, has been measured since the 1980s. These datasets, along with air temperature obtained from a local weather station, were analyzed to assess temporal trends in the air temperature, precipitation acidity, pond temperature, and pond pH, and are interpreted within the context of regional air quality improvements and increasing temperatures from regional climate warming. The results suggest that all parameters have increased significantly during the last several decades. As temperature and pH regulate a wide variety of physical, chemical, and biological processes, these changes may be influencing the overall ecology of the kettle ponds. This analysis provides an opportunity to gauge the future trajectory of this important resource and may ultimately guide management strategies for their continued protection against a backdrop of climate change and atmospheric emission controls.

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Characterizing Nitrogen and Sulfur Deposition in Latin America: Simulation and Evaluation

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Population growth and economic development in Latin America is significantly increasing reactive nitrogen and sulfur emissions that acidify terrestrial and aquatic ecosystems. Multiple studies have been conducted in order to characterize nitrogen and sulfur in the United States and Europe, while few studies have been conducted within Latin America. The goal of this project is to provide a first estimate total deposition of nitrogen and sulfur in Latin America and provide observational constraints.

We use GEOS-Chem (Yantosca et al. 2015) to calculate total N and S deposition and compare to a collection of observations from previous studies accounting for observational artifacts. We collected observations of NO_3N, NH_4N, and SO_4S wet deposition from collectors without automatic closure systems. As a result, observed "wet deposition" includes artifacts from aerosol dry deposition. We predicted deposition using GEOS-Chem v9 with standard emissions options and meteorology from GEOS-5 for all years. Predictions were post processed to create NO_3N, NH_4N, and SO_4S from the sum of wet deposition and particulate dry deposition. We quantified deposition bias in Latin America for nitrogen and sulfur, with artifacts, at 14 sites from 2006-2010.

Normalized mean biases for total deposition of NO_3N, NH_4N, and NO_3N+NH_4N had the following means respectively: .23, -.65, and -.26. The Normalized mean biases for the total depositions of NO_3N, NH_4N, and NO_3N+NH_4N had the following ranges respectively: -3.4 in Sao Paulo, Brazil to 2.1 in Manizales, Columbia. -3.2 in Sao Paulo, Brazil to 2.0 in Rio de Janeiro, Brazil, -6.5 in Sao Paulo, Brazil to 2.2 in Pergamino, Argentina. Sao Paulo, the most populated city within Brazil, consistently produced the largest and most negative normalized mean biases for nitrogen containing species.

Results show that in general, heavily populated cities produce larger and more negative normalized mean biases which suggests that the model is under-predicting total deposition. Total deposition for SO_4S did not show a consistent relationship between modeled and predicted results. Land use from GEOS-Chem will be used in order to determine the urban fraction of the grid scales for each of the 14 sites. The normalized mean biases will be regressed against the urban fraction to identify the role of anthropogenic emissions in the deposition bias. We will determine whether GEOS-Chem is a good predictor and whether it predicts better or worse in urban areas. We will present current results as well as the results from the regression.

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Atmospheric Deposition of PCBs in Northern New Mexico

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Polychlorinated biphenyls (PCBs) are persistent organic pollutants (POPs) that are observed globally in environmental media, even in regions that do not have anthropogenic development or industrial activity. PCBs, which have the potential to cause a variety of adverse health effects, have been detected in surface water and storm water runoff in northern New Mexico, a landscape with sparse industry and urban development. Northern New Mexico has a mild, semiarid, continental climate characterized by low precipitation totals dominated by summer monsoons, low relative humidity, and relatively large diurnal and annual temperature ranges. The elevation ranges from 4,000 to just above 13,000 feet. In order to quantify and understand the PCB source term, wet atmospheric deposition (precipitation) samplers were deployed in 2009 and samples have been collected sporadically since then. The automated samplers were deployed at elevations between 6,500 feet on the Pajarito Plateau and 8,700 feet in the Valles Caldera in the Jemez Mountains. Forty-eight wet deposition samples were analyzed for PCBs using the PCB congener method (EPA Method 1668A). Total PCB values for precipitation, summed from congener results, range from a minimum of 0.002 nanograms/Liter (ng/L) to 4.100 ng/L with an average value of 0.656 ng/L, a median value of 0.358 ng/L, and a standard deviation of 0.876 ng/L. Samplers have been retrofitted to include passive dry atmospheric deposition (i.e., particulate and dust) collection, and two dry deposition samples have been collected to date. The data from this project inform on the probable linkage between PCB concentrations in atmospheric deposition and PCB concentrations observed in surface/storm water in Northern New Mexico.

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A case study of possible relationships between air pollution and tree rings in the northwestern Czech Republic

Joseph Pinto[1] and Ivan Benes[2]

This is a case study illustrating the possible effects of severe air pollution and subsequent recovery on a Canadian Silver Spruce growing in the Northwestern Czech Republic. Differences in the width of tree rings coincide with different air pollution regimes. The width of the rings can be characterized by three distinct regimes: an early growth stage (lasting ~25 years); an intermediate stage consisting of extremely narrow rings (lasting ~ 30 years) and a final stage with broad rings (lasting ~20 years). During the middle stage, the area was subjected to high levels of air pollution (mainly SO_2 and PM). In the middle of the 1990s, effective pollution controls were instituted, resulting in rapid declines in levels of SO_2 and PM.

Periodic inspection of the tree during the intermediate period of heavy pollution revealed little or no insect or fungal parasites and no cones. Spruce aphids appeared only during the past several years resulting in severe loss of needles near the end of the tree's expected lifespan. This observation can be readily explained if insect and fungal pests were also strongly affected by the high levels of air pollution ($54 < SO_2 < 140\ \mu g/m^3$ annual average) found during the middle stage and their population recovered during the years characterized by much lower pollution ($SO_2 < 15\ \mu g/m^3$ annual average). Of course, further studies that rely on isotopic analyses (e.g.) are needed to more clearly make the link between tree growth, altered physiology and air pollution induced stress.

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An overview of changes in wet deposition across the U.S. over the past 25 years

Joseph Pinto[1], Adam Benson[2] and Alan Talhelm[3]

Large differences in wet deposition of nitrate (NO_3^-), ammonium (NH_4^+) and sulfate (SO_4^{2-}) between two three-year periods (1989 to 1991 and 2012 to 2014) are seen across the United States based on data from the NADP/NTN. The magnitude and sign of differences varies regionally and with species. As expected, based on controls mandated by the Clean Air Act Amendments of 1990, the eastern U.S. is characterized by large decreases in wet fluxes of SO_4^{2-} and NO_3^-. Changes in wet fluxes of SO_4^{2-} and NO_3^- in the central and western U.S. are typically not as large with some areas experiencing increases and others decreases. The most notable changes in these regions are associated with increases in wet deposition of SO_4^{2-} and NO_3^- in the North Central U.S. and in southern Idaho. Several studies in the literature have indicated increases in emissions from oil and gas exploration and production in the region, transport from oil and gas fields in Alberta and also expansion of motor vehicles and EGUs to meet the demands of population growth. All of these sources may have contributed to the observed increases in deposition. Concentrated animal feeding and wildfires are other sources of deposition, which might be particularly important in southern Idaho/ northern Utah. Wet deposition at sites in the area is characterized by a high degree of interannual variability. Wildfires are also characterized by a high degree of interannual variability and are known to be increasing in the Intermountain West and may contribute to this observation.

In contrast to SO_4^{2-} and NO_3^-, the largest area-wide increases in wet deposition of NH_4^+ are found in the Central U.S., with notable hot spots in eastern North Carolina, and in the Intermountain West. Increases in wet deposition of NH_4^+ are especially notable in areas characterized by concentrated animal feeding operations. Interestingly, wet deposition of NH_4^+ appears to have decreased in the Gulf States. In general, these results suggest that the ratio of NH_4^+ to NO_3^- in rainwater has increased and in many areas, NH_4^+ is the dominant form of reactive nitrogen. Analyses of trends and interannual variability in deposition at selected individual sites in distinct ecological regions will also be presented.

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Spatial scale variability of NH_3 and impacts to interpolated concentration grids

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Over the past decade, reduced nitrogen (NH_3, NH_4) has become an important component of atmospheric nitrogen deposition due to increases in agricultural activities and reductions in oxidized sulfur and nitrogen emissions from the power sector and mobile sources. Reduced nitrogen is known to cause negative impacts on air quality (i.e. PM2.5 formation) and ecosystems (i.e. eutrophication, soil acidification), yet the fate and transport of reduced nitrogen from emissions sources is not well characterized. Ammonia is believed to be deposited locally around large emissions sources, but it may be deposited and re-emitted or react with acidic gases to form NH_4^+ particulates, allowing for transport and deposition much further downwind. NH_3/NH_4 may also alternate between particulate and gas phases with differing atmospheric and meteorological conditions greatly affecting the fraction which is transported or deposited.

To better characterize NH_3 concentrations on a national scale, NADP's AMoN began measuring bi-weekly NH_3 concentrations in 2012 and has grown to nearly 100 monitoring sites. Many of the sites that began measuring in 2007 have shown an increasing trend in NH_3 concentrations, but little is known about how concentrations vary between site locations.

A field experiment was conducted where ambient NH_3 was measured using the AMoN passive samplers at 17 sites located around the Fort Collins, CO AMoN site (CO13) and 9 sites around the University of Illinois Bondville monitoring station (IL11). Samplers were deployed for 1-year resulting in ~10 samples per location. The two different locations were selected based on their difference in terms of land-use, source type, and the proximity of sampling locations to those sources. The Fort Collins area is heavily influenced by large CAFOs to the east in Weld county and complex terrain to the west (Rocky Mountain National Park). Bondville is surrounded mostly by crop fields and fertilization.

A spatial model was used to evaluate the bi-weekly variability between the samples in each region. The results are used to determine a reasonable radius of influence around an AMoN site. The calculated variability may be used to modify the radius of influence used in the total deposition hybrid maps developed by NADP's TDEP committee. The current method for calculating a seasonal radius of influence for NH_3 was derived from gridded CMAQ estimates of NH_3concentrations. Further work needs to be done to determine how local source impacts may be used to determine the radius of influence from AMoN in the TDEP interpolation method.

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The potential effect of climate change on critical loads of nitrogen in Class I wilderness areas of the Northeastern United States

Molly Robin-Abbott[1], Linda H. Pardo[2], Jennifer Pontius[3] and Jason Coombs[4]

We have developed a GIS tool (N-CLAS) that allows federal land managers, policy makers, and other interested parties to calculate site-based critical loads of nitrogen (N) and exceedance for the northeastern United States. N-CLAS is based on species-specific tables that set optimal growth thresholds for multiple soil, site, and climate parameters. N-CLAS critical loads can be calculated for all species at a site or a subset of species. Calculations determine whether growth conditions are optimal or sub-optimal. When conditions are sub-optimal, the site will be more susceptible to detrimental impacts of N deposition, and the adjusted critical load will be in the lower half of the critical load range. Changing site conditions will result in altered critical loads. Climate change, harvesting, insect pests, fungal pathogens, and natural disasters can all affect growth conditions, site N-cycling, and critical loads. Here we use maps and tables generated with N-CLAS to compare critical loads of N and exceedance for Class I areas in the Northeastern United States under current conditions and with the Hadley CM3 high (no change in current emissions) climate change scenarios.

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Estimating Total Deposition Using NADP and CASTNET Data

Christopher Rogers[1], Robert Larson[2], Melissa Puchalski[3], Donna Schwede[4], Gary Lear[5] and David Gay[6]

For more than 40 years, efforts have been made to estimate total sulfur and nitrogen deposition in the United States using a combination of measured concentrations in precipitation and in the air, precipitation amounts for wet deposition, and various modeled or estimated deposition velocities for dry deposition. Long-term monitoring of sulfur and nitrogen pollutants has provided program accountability under the Clean Air Act Amendments and other EPA emission reduction programs. Initially, interest in deposition resulted from the focus on acid rain and the impacts on property and ecosystems from this phenomenon, which was dominated by sulfur species. Ambient sulfur concentrations and deposition have decreased dramatically in the Eastern United States (~60% and ~85%, respectively) between 1990 and 2013. Reductions in nitrogen species have been less dramatic and associated deposition and ecosystem impacts, including critical loads applications, have gained more interest within the scientific community.
The National Atmospheric Deposition Program (NADP) has operated the National Trends Network (NTN) since 1978 and the Atmospheric Integrated Research Monitoring Network (AIRMoN) since 1992. Both networks measure concentrations of anions and cations in precipitation and use precipitation amounts to calculate wet deposition. NTN currently features more than 250 sites measuring weekly concentrations and AIRMoN has six sites measuring event-based concentrations. The Clean Air Status and Trends Network (CASTNET) was established in 1987 to assess trends in ambient air quality and deposition of acidic pollutants due to emission reduction programs. CASTNET currently operates more than 90 sites. CASTNET uses a filter pack and active flow system to measure weekly integrated ambient air samples of species similar to those measured by NADP. CASTNET methodology includes combining concentrations with estimated deposition velocities to calculate dry deposition.
Numerous methods have been employed using NADP and CASTNET data to estimate total deposition. Ideally, the two networks act as sister networks, each providing part of the total deposition. NADP initially used precipitation amounts from onsite raingages only, but currently incorporates PRISM modeled precipitation amounts to allow for improved resolution between site locations and in complex terrain. CASTNET has historically used the Multi-layer model (MLM) to estimate deposition velocities to get point estimates of dry deposition. For sulfur species, combining the NADP and CASTNET wet and dry deposition estimates was an adequate method. However, the increased interest in nitrogen deposition showed that this method was missing key components of total nitrogen deposition including ammonia dry deposition, organic nitrogen in both wet and dry deposition, and the dry deposition of other non-measured species (i.e. NO_2, HONO, PAN). Recently, the NADP Total Deposition Science Committee (TDEP) has developed a hybrid method combining the measurements of NADP and CASTNET with the model output from EPA's Community Multiscale Air Quality (CMAQ) model to provide continuous spatial and temporal estimates of total deposition. Modeled estimates provide non-measured pollutants and improve the understanding of the complicated processes that make up total deposition estimates.

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Measurement of air-surface exchange of speciated nitrogen and sulfur compounds in a coastal environment

Ian Rumsey[1] and John T. Walker[2]

Ecosystem exposure and vulnerability to atmospheric deposition of nitrogen and sulfur compounds is increasingly being assessed by the United States Environmental Protection Agency's (U.S. EPA's) primary regulatory tool, the Community Multiscale Air Quality Model (CMAQ). Further development of the model's dry deposition algorithms requires observational datasets across a range of different conditions including variations in meteorology, atmospheric chemistry and surface conditions. Observational datasets for coastal environments, which often have different meteorological and atmospheric chemistry conditions in comparison to inland, have historically been data-limited with respect to direct dry deposition measurements. Therefore, such datasets, will help determine the influence of coastal atmospheric physical and chemical processes on speciated dry nitrogen and sulfur deposition. In this study, the Monitor for AeRosols and GAses in ambient air (MARGA) instrument is deployed in a coastal environment near Charleston, South Carolina. The MARGA is an on-line ion-chromatography-based measurement instrument which simultaneously measures multiple gas and aerosol species at an hourly resolution, allowing the opportunity to develop long term multi-species air-surface exchange measurements. This study uses the MARGA 2S system, which includes two sampling boxes interfaced to a single analytical instrument. Concentration measurements are used in conjunction with the micrometeorological aerodynamic gradient method to determine air-surface exchange fluxes of gases (NH_3, HNO_3, HNO_2, and SO_2) and aerosols (NH_4^+, NO_3^-, and SO_4^{2-}). The presentation describes preliminary measurements of air concentrations and fluxes above a grass field, during the late summer and fall of 2016. The general features of compound-specific concentrations and fluxes, including relationships with atmospheric physical and chemical processes, are discussed.

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A Handbook of Tree Species Responses to Nitrogen Deposition

Robert D. Sabo[1], Christopher Clark[2], Linda Pardo[3], Tara Greaver[4], Jeffrey Herrick[5], Kevin Horn[6], Quinn Thomas[7] and Linda Geiser[8]

Trees provide a variety of ecosystem good and services that are vital to maintaining the social, economic, and environmental well-being of our nation. A variety of anthropogenic and natural stressors, however, compromise the growth, recruitment, and survival of many forest tree species. These stressors, like drought, fire, pest outbreaks, and overharvesting, undermine the ecological processes that maintain the goods and services we derive from trees and forests. Atmospheric deposition of nitrogen (N) is one primary, anthropogenic stressor to tree species that alters tree growth rates, accelerates soil acidification, increases nitrate (NO3-) leaching which impairs downstream surface waters, and compromises important tree and mycorrhizal relationships. Implementation of the Clean Air Act and the 1990 Amendments has resulted in steadily declining emissions of oxidized N (NOx), and has resulted in significant declines in deposition across much of the eastern United States. Rates of atmospheric N deposition are still high relative to preindustrial times, however. This fact warrants an updated assessment of individual tree species' vulnerabilities to current rates of deposition across the USA and associated alteration of ecological processes and ecosystem goods and services. The purpose of this report is to summarize the potential impacts from N deposition on 89 tree species across the continental US for which there is sufficient data to draw statistically robust conclusions about ecological impacts. Inferences are drawn from the species-specific national-scale growth and mortality responses developed in Horn et al. (en prep), combined with ecological and ecosystem service information mainly acquired through the Fire Effects Information System. Together these provide information on how each species responds to N deposition, as well as the ecology and ecosystem services provided by these species. Specifically each species page presents five categories of information: (1) the reported range and abundance, (2) the associated N deposition across that range, (3) the species' growth and mortality responses to N deposition, (4) a basic description of the ecology of and ecosystem processes supported by the species, and (5) a summary of the ecosystem goods and services provided by the species. This report will be a valuable, accessible reference manual for land managers and policy makers looking to assess species vulnerability to atmospheric N deposition, but also useful for economic and environmental researchers needing a centralized, succinct compendium describing species-specific ecological processes, ecosystem services, and datasets relevant to assessing tree species response to atmospheric N deposition.

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Conceptual Approach for Analyzing the Impact of Atmospheric Sulfur Deposition on Methylmercury Concentrations in Freshwater Streams

Randy Waite[1], David Krabbenhoft[2], Jennifer Richkus[3], Vicki Sandiford[4], Ginger Tennant[5], Tara Greaver[6], Emmi Felker-Quinn[7] and Marion Deerhake[8]

This poster describes a draft conceptual risk assessment approach for analyzing the impacts of atmospheric sulfur deposition on mercury sensitive freshwater streams on a broad geographic scale. We will investigate the impact of changing sulfur deposition on concentrations of methylmercury in the streams. We will identify areas where atmospheric deposition of sulfur is the primary contributing source to the total sulfur concentration in the streams. This will allow us to more easily investigate the relationship between atmospheric and aquatic sulfur concentrations, and potentially make some general assumptions about how a change in atmospheric concentrations will affect aquatic methylmercury conditions.

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Importance of Nitrogen Deposition to Freshwater Streams in the US.

Randy Waite[1], Ginger Tennant[2], Tara Greaver[3], Michele Eddy[4], Benjamin Lord[5], Jaime Cajka[6] and Marion Deerhake[7]

This poster describes a coarse scale data compilation and analysis of nitrogen loads to freshwater bodies in select states to examine where atmospheric nitrogen deposition is sufficient to surpass tipping points that exceed nitrogen water quality criteria for individual waterbodies. The goal of this project is to identify locations throughout the country where a reduction in atmospheric nitrogen deposition might improve water quality conditions from an impaired to a recovered state. In locations where a reduction in atmospheric nitrogen deposition is predicted to mitigate impairment, the necessary load reduction is expressed as an estimated percent of the long-term atmospheric nitrogen deposition loading estimated for the site from existing data. This analysis utilizes sites sampled during the National River and Streams Assessment (NRSA). Data on each NRSA site were gathered that identified the dominant nitrogen source, any intersecting impaired waters, and applicable water quality criteria. Calculations were also performed on the water chemistry information collected for each site to determine whether the site is nitrogen-limited, phosphorus-limited, or co-limited.

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Characterization of chromatography related performance of the Monitor for AeRosols and GAses in ambient air (MARGA)

John Walker[1] and Xi Chen[2]

The Monitor for AeRosols and GAses in ambient air (MARGA) is an on-line ion-chromatography-based instrument designed for speciation of the inorganic gas and aerosol ammonium-nitrate-sulfate system. Previous work to characterize the performance of the MARGA has been primarily based on field comparison to other measurement methods to evaluate accuracy. While such studies are useful, the underlying reasons for disagreement among methods are not always clear. This study examines aspects of MARGA accuracy and precision specifically related to automated chromatography analysis. Using laboratory standards, analytical accuracy, precision, and method detection limits derived from the MARGA chromatography software are compared to an alternative software package (Chromeleon, Thermo Scientific Dionex). Field measurements are used to further evaluate instrument performance, including the MARGA's use of an internal LiBr standard to control accuracy. Using gas/aerosol ratios and aerosol neutralization state as a case study, the impact of chromatography on measurement error is assessed.

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Total and monomethylmercury and major ions in coastal California fog water: Results from two years of sampling on land and at sea

Peter Weiss-Penzias[1], Kenneth Coale[2], Wes Heim[3], Dan Fernadez[4], Andrew Oliphant[5], Celeste Dodge[6], Dave Hoskins[7] and James Farlin[8]

Marine fog water samples were collected over two summers (2014–2015) with active strand collectors (CASCC) at eight coastal sites from Humboldt to Monterey counties in California, USA, and on four ocean cruises along the California coastline in order to investigate mercury (Hg) cycling at the ocean-atmosphere-land interface. The mean concentration of monomethylmercury (MMHg) in fog water across terrestrial sites for both years was 1.6 ± 1.9 ng L-1 (<0.01–10.4 ng L-1, N = 149), which corresponds to 5.7% (2.0–10.8%) of total Hg (HgT) in fog. Rain water samples from three sites had mean MMHg concentrations of 0.20 ± 0.12 ng L-1 (N = 5) corresponding to 1.4% of HgT. Fog water samples collected at sea had MMHg concentrations of 0.08 ± 0.15 ng L-1 (N = 14) corresponding to 0.4% of HgT. Significantly higher MMHg concentrations in fog were observed at terrestrial sites next to the ocean relative to a site 40 kilometers inland, and the mean difference was 1.6 ng L-1. Using a rate constant for photo-demethylation of MMHg of -0.022 h-1 based on previous demethylation experiments and a coastal-inland fog transport time of 12 hours, a mean difference of only 0.5 ng L-1 of MMHg was predicted between coastal and inland sites, indicating other unknown source and/or sink pathways are important for MMHg in fog. Fog water deposition to a standard passive 1.00 m2 fog collector at six terrestrial sites averaged 0.10 ± 0.07 L m-2 d-1, which was ~2% of typical rainwater deposition in this area. Mean air-surface fog water fluxes of MMHg and HgT were then calculated to be 34 ± 40 ng m-2 y-1 and 546 ± 581 ng m-2 y-1, respectively. These correspond to 33% and 13% of the rain fluxes, respectively.

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Bias between N-CON and AeroChem precipitation collectors: Effects on trends and deposition maps for the National Atmospheric Deposition Program / National Trends Network

Gregory Wetherbee[1]

The National Atmospheric Deposition Program (NADP) approved the N-CON Systems, Inc. ADS 00-120 precipitation-sample collector (NCON) as a replacement for the Aerochem Metrics model 301 collector (ACM) for the National Trends Network (NTN) in 2010. To date, approximately one-third of the NTN ACM collectors have been replaced with NCON collectors, primarily at sites supported by the U.S. Geological Survey (USGS). Aerochem Metrics stopped producing collectors circa 1996. Recent USGS investigation into potential colocated (paired) collector bias indicates wet-deposition samples from NCON collectors generally have higher solute concentrations compared to samples collected in ACM equipment, thus shifts in temporal trends for retrofitted sites and changes in spatial variability of wet-deposition concentrations across the network have been anticipated.

Colocated (paired) ACM and NCON collectors were operated at 12 NTN sites located in various precipitation regimes, resulting in 15 site-years of record. Linear regression models, which related the paired collector data for all sites combined, were calculated for each NTN analyte excluding bromide and specific conductance. The regression equations were applied to archived NTN data, collected using ACM equipment, to obtain model-adjusted concentration values for complete records from 18 NTN sites. These 18 sites were separate from the group of colocated (paired) sites. Temporal trends for the original (actual) and model-adjusted data were compared for these 18 sites. Results indicate small shifts in 10-year seasonal precipitation-weighted mean concentration (PWMC) trend slopes for overall cations (-0.001 to -0.007 $mgL^{-1}yr^{-1}$), for overall anions (-0.009 to -0.028 $mgL^{-1}yr^{-1}$), and for hydrogen ion (+0.689 $meqL^{-1}yr^{-1}$). Shifts in NO_3^- and SO_4^{-2} seasonal PWMC trend slopes were greater in the Midwest and Northeast US compared to other regions using the adjusted data.

Spatially interpolated annual PWMC maps for original and model-adjusted data were also compared using ArcMap 9.3.1. Analysis of geospatially interpolated PWMC data illustrated that incorporation of the NCON collectors into the NTN has changed the spatial variability in NADP's Annual Summary maps.

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Using deuterium excess to track annual and interannual contribution of tropical moisture to the west coast of the United States

Jessica Zaiss[1], Lowell Stott[2] and Nikolaus Buenning[3]

As global temperatures rise, water stressed regions along the western coast of the United States could become increasingly drier due to projected northward shifts in storm trajectories over the 21st century. Assessing the variations in moisture source and delivery that could accompany these atmospheric changes will greatly benefit future water management practices. To determine if shifts in moisture transport can be detected in isotopic tracers, we are continuously measuring the isotopic composition of precipitation collected at 18 NADP sites along the west coast of the United States. Sites with longer records offer continuous sampling as far back as 2001. Oxygen and hydrogen isotopes in precipitation provide a record of variability within the hydrological cycle at all spatial and temporal scales via fractionation effects. Additionally, a second order variable, deuterium excess (d-excess = $\delta D - 8*\delta^{18}O$), records changes in the source of the water vapor. Results from these measurements show no significant trends in δD or $\delta^{18}O$ over the past 15 years. However, deuterium excess values do vary systematically on both seasonal and interannual time scales. The seasonal cycle consists of higher deuterium excess values in the winter and lower deuterium excess values in the summer. Interannual variability is expressed as an increase in deuterium excess values over approximately four water years followed by a marked decrease for one water year. Because moisture originating in the tropics carries an isotopically heavier signal than does extratropical moisture, we hypothesize that both the annual and interannual variability described here is indicative of changing proportions in the amount of tropically sourced moisture. Interannual variations in meridional wind patterns are consistent with this hypothesis.

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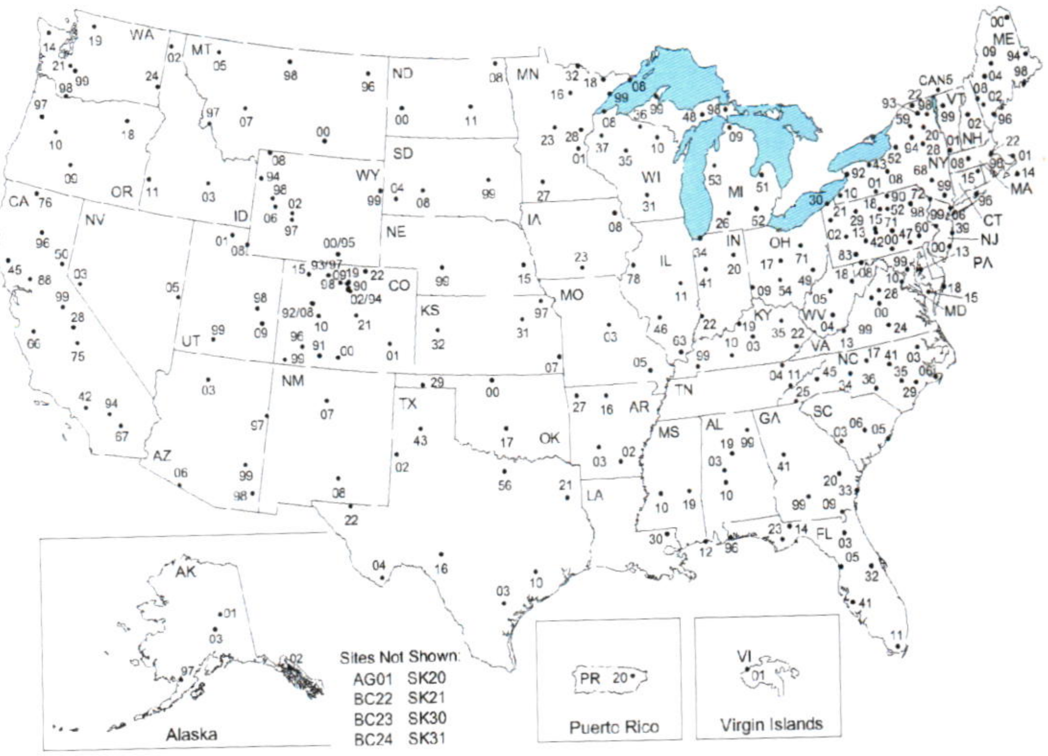
NTN Map and Site Listings

National Atmospheric Deposition Program
National Trends Network



National Atmospheric Deposition Program/National Trends Network Sites

July 31, 2016

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL03	Centerville	MDN	Southern Company/Atmospheric Research & Analysis, Inc.	02/11
AL10	Black Belt Research & Extension Center		US Geological Survey	08/83
AL19	Birmingham	MDN	Southern Company/Atmospheric Research & Analysis, Inc.	12/12
AL99	Sand Mountain Research & Extension Center	AMoN	US Environmental Protection Agency-CAM	10/84
Alaska				
AK01	Poker Creek		USDA Forest Service	12/92
AK02	Juneau		USDA Forest Service	06/04
AK03	Denali NP - Mount McKinley	AMNet	National Park Service - Air Resources Division	06/80
AK06	Gates of the Arctic NP - Bettles	MDN	US Bureau of Land Management	11/08
AK97	Katmai National Park - King Salmon		National Park Service - Air Resources Division	11/09
Argentina				
AG01	Laurenti-MAR		NOAA-Air Resources Lab	10/11
Arizona				
AZ03	Grand Canyon NP - Hopi Point		National Park Service - Air Resources Division	08/81
AZ06	Organ Pipe Cactus NM		National Park Service - Air Resources Division	04/80
AZ97	Petrified Forest NP-Rainbow Forest		National Park Service - Air Resources Division	12/02
AZ98	Chiricahua	AMoN	US Environmental Protection Agency-CAM	02/99
AZ99	Oliver Knoll		US Geological Survey	08/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Arkansas				
AR02	Warren 2WSW		US Geological Survey	05/82
AR03	Caddo Valley	AMoN	US Geological Survey	12/83
AR16	Buffalo NR - Buffalo Point		National Park Service - Air Resources Division	07/82
AR27	Fayetteville		US Geological Survey	05/80
California				
CA28	Kings River Experimental Watershed		USDA Forest Service	04/07
CA42	Tanbark Flat		USDA Forest Service	01/82
CA45	Hopland		US Geological Survey	10/79
CA50	Sagehen Creek		US Geological Survey	11/01
CA66	Pinnacles NM - Bear Valley		National Park Service - Air Resources Division	11/99
CA67	Joshua Tree NP - Black Rock	AMoN	National Park Service - Air Resources Division	09/00
CA75	Sequoia NP - Giant Forest	MDN	National Park Service - Air Resources Division	07/80
CA76	Montague		US Geological Survey	06/85
CA88	Davis		US Geological Survey	09/78
CA94	Converse Flats	MDN	USDA Forest Service	05/06
CA96	Lassen Volcanic NP - Manzanita Lake		National Park Service - Air Resources Division	06/00
CA99	Yosemite NP - Hodgdon Meadow		National Park Service - Air Resources Division	12/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Colorado				
CO00	Alamosa		US Geological Survey	04/80
CO01	Las Animas Fish Hatchery		US Geological Survey	10/83
CO02	Niwot Saddle		NSF-Institute of Arctic & Alpine Research/University of CO	06/84
CO08	Four Mile Park		US Environmental Protection Agency-CAM	12/87
CO09	Kawaneechee Meadow		Grand County Water Information Network	07/12
CO10	Gothic	AMoN	US Environmental Protection Agency-CAM	02/99
CO15	Sand Spring		US Bureau of Land Management	03/79
CO19	Rocky Mountain NP - Beaver Meadows		National Park Service - Air Resources Division	05/80
CO21	Manitou		USDA Forest Service	10/78
CO22	Pawnee		National Park Service - Air Resources Division	05/79
CO90	Niwot Ridge-Southeast		NSF-Institute of Arctic & Alpine Research/University of CO	01/06
CO91	Wolf Creek Pass		USDA Forest Service	05/92
CO92	Sunlight Peak		US Environmental Protection Agency-CAM	01/88
CO93	Buffalo Pass - Dry Lake		USDA Forest Service	10/86
CO94	Sugarloaf		US Environmental Protection Agency-CAM	11/86
CO96	Molas Pass	MDN	USDA Forest Service	07/86
CO97	Buffalo Pass - Summit Lake	MDN	USDA Forest Service	02/84
CO98	Rocky Mountain NP - Loch Vale	AMoN	USGS/Colorado State University	08/83
CO99	Mesa Verde NP - Chapin Mesa	MDN	US Geological Survey	04/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Connecticut				
CT15	Abington	AMoN	US Environmental Protection Agency-CAM	01/99
Florida				
FL03	Bradford Forest		US Environmental Protection Agency-CAM	10/78
FL05	Chassahowitzka NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	08/96
FL11	Everglades NP - Research Center	MDN AMoN	National Park Service - Air Resources Division	06/80
FL14	Quincy		US Geological Survey	03/84
FL23	Sumatra	AMoN	US Environmental Protection Agency-CAM	01/99
FL32	Orlando		Orange County Government	12/05
FL41	Verna Well Field		US Geological Survey	08/83
FL96	Pensacola	AMNet MDN	Southern Company Atmospheric Research & Analysis, Inc.	01/13
Georgia				
GA09	Okefenokee NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	06/97
GA20	Bellville		US Environmental Protection Agency-CAM	04/83
GA33	Sapelo Island	MDN	NSF UGA, & GA Dept. of Natural Resources	11/02
GA41	Georgia Station	AMoN	Southern Company Atmospheric Research & Analysis, Inc.	10/78
GA99	Chula		US Geological Survey	02/94
Idaho				
ID02	Priest River Experimental Forest		USDA Forest Service	12/02
ID03	Craters of the Moon NM	AMoN	National Park Service - Air Resources Division	08/80
ID11	Reynolds Creek		US Geological Survey	11/83

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Illinois				
IL11	Bondville	AIRMoN/ MDN/AMoN	US Environmental Protection Agency-CAM	02/79
IL46	Alhambra	AMoN	US Environmental Protection Agency-CAM	01/99
IL63	Dixon Springs Agricultural Center	MDN	SAES-University of Illinois	01/79
IL78	Monmouth		US Geological Survey	01/85
Indiana				
IN20	Roush Lake	AMoN	US Geological Survey	08/83
IN22	Southwest Purdue Agriculture Center	MDN/AMoN	US Geological Survey	09/84
IN34	Indiana Dunes NL	MDN	National Park Service - Air Resources Division	07/80
IN41	Agronomy Center for Research and Extension		SAES-Purdue University	07/82
Iowa				
IA08	Big Springs Fish Hatchery		US Geological Survey	08/84
IA23	McNay Memorial Research Center		US Geological Survey	09/84
Kansas				
KS07	Farlington Fish Hatchery		US Geological Survey	03/84
KS31	Konza Prairie	AMoN	SAES-Kansas State University	08/82
KS32	Lake Scott State Park	MDN	US Geological Survey	03/84
KS97	Kickapoo	AMoN	Kickapoo Tribe in Kansas	10/15

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Kentucky				
KY03	Mackville	AMoN	US Geological Survey	11/83
KY10	Mammoth Cave NP-Houchin Meadow	MDN	National Park Service - Air Resources Division	08/02
KY19	Seneca Park		US Geological Survey	10/03
KY22	Lilley Cornett Woods		US Geological Survey	09/83
KY35	Clark State Fish Hatchery		US Geological Survey	08/83
KY99	Mulberry Flats		Murray State University	12/94
Louisiana				
LA12	Iberia Research Station		US Geological Survey	11/82
LA30	Southeast Research Station		US Geological Survey	01/83
Maine				
ME00	Caribou	MDN	EPA/Maine Dept. of Environmental Protection	04/80
ME02	Bridgton	MDN	EPA/Maine Dept. of Environmental Protection	09/80
ME04	Carrabassett Valley	MDN	US Environmental Protection Agency - CAM	03/02
ME08	Gilead		US Geological Survey	09/99
ME09	Greenville Station	MDN	EPA/Maine Dept. of Environmental Protection	11/79
ME94	Indian Township		Passamaquoddy Tribe/EPA	10/13
ME96	Casco Bay - Wolfe's Neck Farm	MDN	EPA/Maine Dept. of Environmental Protection	01/98
ME98	Acadia NP - McFarland Hill	MDN	National Park Service - Air Resources Division	11/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Maryland				
MD08	Piney Reservoir	MDN/AMNet/ AMoN	Maryland Department of Natural Resources	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/AMNet AMoN	Maryland Department of Natural Resources	06/04
Massachusetts				
MA01	North Atlantic Coastal Lab	MDN	National Park Service - Air Resources Division	12/81
MA08	Quabbin Reservoir		Northeast States for Coordinated Air Use Management	03/82
MA14	Nantucket		Nantucket Land Council	03/14
MA22	Boston University		Boston University - Department of Biology	06/15
MA98	Arnold Arboretum		Arnold Arboretum of Harvard University	02/16
Michigan				
MI09	Douglas Lake	MDN	SAES-Michigan State University	07/79
MI26	Kellogg Biological Station	MDN	SAES-Michigan State University	06/79
MI48	Seney NWR - Headquarters	MDN	US Fish & Wildlife Service - Air Quality Branch	11/00
MI51	Unionville	AMoN	US Environmental Protection Agency-CAM	01/99
MI52	Ann Arbor	MDN/AMoN	US Environmental Protection Agency-CAM	01/99
MI53	Wellston		USDA Forest Service	10/78
MI98	Raco		US Environmental Protection Agency-CAM	05/84
MI99	Chassell		USDA Forest Service	02/83

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Minnesota				
MN01	Cedar Creek		Minnesota Pollution Control Agency	12/96
MN08	Hovland		Minnesota Pollution Control Agency	12/96
MN16	Marcell Experimental Forest	MDN	USDA Forest Service	07/78
MN18	Fernberg	MDN AMoN	US Environmental Protection Agency-CAM	11/80
MN23	Camp Ripley	MDN	US Geological Survey	10/83
MN27	Lamberton	MDN	Minnesota Pollution Control Agency	01/79
MN28	Grindstone Lake		Minnesota Pollution Control Agency	12/96
MN32	Voyageurs NP - Sullivan Bay		National Park Service - Air Resources Division	05/00
MN99	Wolf Ridge		Minnesota Pollution Control Agency	12/96
Mississippi				
MS10	Clinton		US Geological Survey	07/84
MS12	Grand Bay NERR	MDN AMNet	NOAA-Air Resources Lab	03/10
MS19	Newton		NOAA-Air Resources Lab	11/86
MS30	Coffeeville	AMoN	USDA Forest Service	07/84
Missouri				
MO03	Ashland Wildlife Area		US Geological Survey	10/81
MO05	University Forest		US Geological Survey	10/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Montana				
MT00	Little Bighorn Battlefield NM		US Geological Survey	07/84
MT05	Glacier NP - Fire Weather Station	MDN	National Park Service - Air Resources Division	06/80
MT07	Clancy		US Geological Survey	01/84
MT96	Poplar River		EPA/Fort Peck Tribes	12/99
MT97	Lost Trail Pass		USDA Forest Service	09/90
MT98	Havre - Northern Agricultural Research Center		US Geological Survey	07/85
Nebraska				
NE15	Mead	MDN	SAES-University of Nebraska	07/78
NE99	North Platte Agricultural Experiment Station		US Geological Survey	09/85
Nevada				
NV03	Smith Valley		US Geological Survey	08/85
NV05	Great Basin NP - Lehman Caves		National Park Service - Air Resources Division	01/85
New Hampshire				
NH02	Hubbard Brook	AMoN	USDA Forest Service	07/78
New Jersey				
NJ00	Edwin B Forsythe NWR		US Fish & Wildlife Service - Air Quality Branch	10/98
NJ39	Cattus Island County Park		US Environmental Protection Agency - CAM	12/12
NJ99	Washington Crossing		US Environmental Protection Agency - CAM	08/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
New Mexico				
NM07	Bandelier NM		National Park Service-Air Resources Division	06/82
NM08	Mayhill		US Geological Survey	01/84
New York				
NY01	Alfred		US Geological Survey	08/04
NY06	Bronx	AMNet/MDN	NYSERDA	01/13
NY08	Aurora Research Farm		USDA/Cornell University	04/79
NY10	Chautauqua		US Geological Survey	06/80
NY20	Huntington Wildlife	MDN/AMNet/ AMoN	NYSERDA	10/78
NY22	Akwesasne Mohawk - Fort Covington		US Environmental Protection Agency - CAM	08/99
NY28	Piseco Lake		NYSERDA	12/12
NY43	Rochester	MDN/AMNet	NYSERDA	04/13
NY52	Bennett Bridge		US Environmental Protection Agency-CAM	06/80
NY59	Wanakena		NYSERDA	01/13
NY68	Biscuit Brook	MDN	US Geological Survey	10/83
NY92	Amherst		NYSERDA	10/13
NY93	Paul Smith's		NYSERDA	01/13
NY94	Indian Township	AMoN	NYSERDA	11/15
NY96	Cedar Beach, Southold	MDN/AMoN	Suffolk Dept. of Health Service-Peconic Estuary Program	11/03
NY98	Whiteface Mountain	AMoN	US Geological Survey	07/84
NY99	West Point		US Geological Survey	09/83

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
North Carolina				
NC03	Lewiston		North Carolina State University/US Geological Survey	10/78
NC06	Beaufort	AMoN	US Environmental Protection Agency-CAM	01/99
NC25	Coweeta	AMoN	USDA Forest Service	07/78
NC29	Hofmann Forest		US Geological Survey	07/02
NC34	Piedmont Research Station		North Carolina State University	10/78
NC35	Clinton Crops Research Station	AMoN	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		US Environmental Protection Agency-CAM	11/85
North Dakota				
ND00	Theodore Roosevelt NP-Painted Canyon		National Park Service-Air Resources Division	01/01
ND08	Icelandic State Park		US Geological Survey	10/83
ND11	Woodworth		US Geological Survey	11/83
Ohio				
OH09	Oxford	AMoN	US Geological Survey	08/84
OH17	Delaware		USDA Forest Service	10/78
OH49	Caldwell		US Geological Survey	09/78
OH54	Deer Creek State Park	AMoN	US Environmental Protection Agency-CAM	01/99
OH71	Wooster		US Geological Survey	09/78

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Oklahoma				
OK00	Salt Plains NWR		US Geological Survey	12/83
OK17	Kessler Farm Field Laboratory		NOAA-Air Resources Lab	03/83
OK29	Goodwell Research Station		US Geological Survey	01/85
Oregon				
OR09	Silver Lake Ranger Station		US Geological Survey	08/83
OR10	H J Andrews Experimental Forest		USDA Forest Service	05/80
OR18	Starkey Experimental Forest		US Geological Survey	03/84
OR97	Hyslop Farm		US Environmental Protection Agency-CAM	04/83
Pennsylvania				
PA00	Arendtsville	MDN/AMoN	US Environmental Protection Agency-CAM	01/99
PA02	Crooked Creek Lake		PA Dept. of Env. Protection/Penn State University	07/11
PA13	Allegheny Portage Railroad National Historic Sit	MDN	PA Dept. of Env. Protection/Penn State University	07/11
PA15	Penn State	AIRMoN	NOAA-Air Resources Lab/PA Game Commission	06/83
PA18	Young Woman's Creek	MDN	US Geological Survey	04/99
PA21	Goddard State Park	MDN	PA Dept. of Env. Protection/Penn State University	07/11
PA29	Kane Experimental Forest	MDN/AMoN	USDA Forest Service	07/78
PA30	Erie	MDN	PA Dept. of Env. Protection/Penn State University	07/11
PA42	Leading Ridge	MDN	PA Dept. of Env. Protection/Penn State University/SAES	04/79
PA47	Millersville	MDN	PA Dept. of Env. Protection/Penn State University	11/02
PA52	Little Pine State Park	MDN	PA Dept. of Env. Protection/Penn State University	07/11
PA60	Valley Forge	MDN	PA Dept. of Env. Protection/Penn State University	07/11

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
PA71	Little Buffalo State Park		PA Dept. of Env. Protection/Penn State University	07/11
PA72	Milford	MDN	USDA Forest Service	12/83
PA83	Laurel Hill State Park		PA Dept. of Env. Protection/Penn State University	07/11
PA90	Hills Creek State Park	MDN	PA Dept. of Env. Protection/Penn State University	07/11
PA98	Frances Slocum State Park		PA Dept. of Env. Protection/Penn State University	07/11
Puerto Rico				
PR20	El Verde	MDN/AMoN	USDA Forest Service	02/85
South Carolina				
SC03	Savannah River	MDN	Savannah River Nuclear Solution, LLC	12/11
SC05	Cape Romain NWR	MDN/AMoN	US Fish & Wildlife Service - Air Quality Branch	11/00
SC06	Santee NWR		US Geological Survey	07/84
South Dakota				
SD04	Wind Cave National Park-Elk Mountain		National Park Service - Air Resources Division	11/02
SD08	Cottonwood		US Geological Survey	10/83
SD99	Huron Well Field		US Geological Survey	11/83
Tennessee				
TN04	Speedwell		US Environmental Protection Agency-CAM	01/99
TN11	Great Smoky Mountain NP - Elkmont	MDN	National Park Service - Air Resources Division	08/80
TN14	Hatchie NWR		US Geological Survey	10/84
Texas				
TX02	Muleshoe NWR		US Geological Survey	06/85
TX03	Beeville		US Geological Survey	02/84

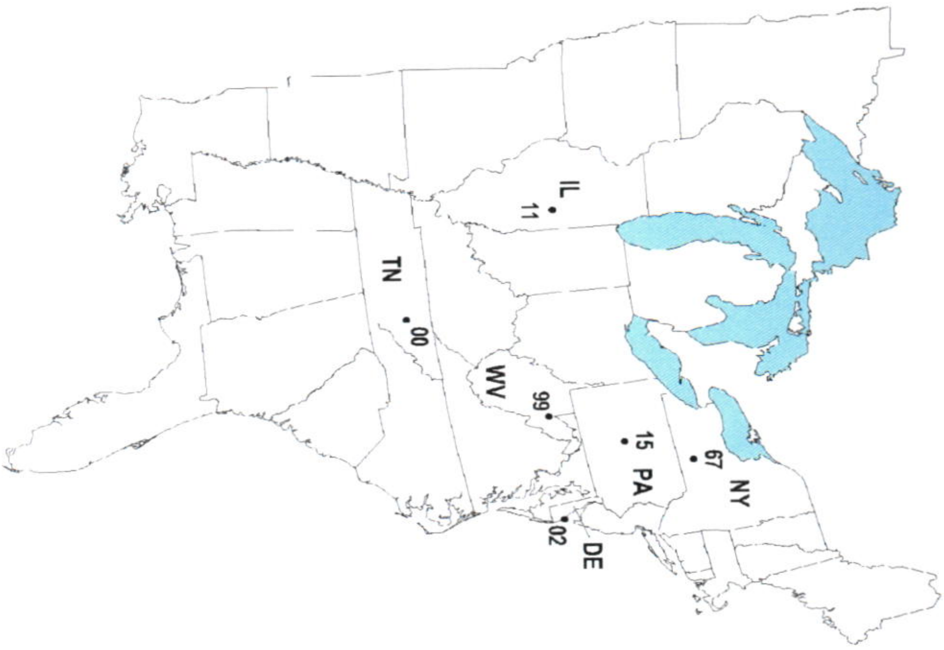
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
TX04	Big Bend NP - K-Bar		National Park Service - Air Resources Division	04/80
TX10	Attwater Prairie Chicken NWR		US Geological Survey	07/84
TX16	Sonora		US Geological Survey	06/84
TX21	Longview	MDN	Texas Commission on Environmental Quality	06/82
TX22	Guadalupe Mountains NP-Frijole Ranger Stn		US Geological Survey	06/84
TX43	Cañónceta	AMoN	US Environmental Protection Agency-CAM	07/07
TX56	LBJ National Grasslands		US Geological Survey	09/83
Utah				
UT01	Logan	AMoN	US Geological Survey	12/83
UT09	Canyonlands NP - Island in the Sky	AMoN	National Park Service - Air Resources Division	11/97
UT98	Green River		US Geological Survey	04/85
UT99	Bryce Canyon NP - Repeater Hill		National Park Service - Air Resources Division	01/85
Vermont				
VT01	Bennington		US Geological Survey	04/81
VT99	Underhill	MDN/AMoN	US Geological Survey	06/84
Virgin Islands				
VI01	Virgin Islands NP - Lind Point		National Park Service - Air Resources Division	04/98
Virginia				
VA00	Charlottesville		US Geological Survey	10/84
VA13	Horton's Station	AMoN	US Environmental Protection Agency-CAM	07/78
VA24	Prince Edward	AMoN	US Environmental Protection Agency-CAM	01/99
VA28	Shenandoah NP - Big Meadows	MDN	National Park Service - Air Resources Division	05/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
VA99	Natural Bridge Station		USDA Forest Service - Air Program	07/02
Washington				
WA14	Olympic NP - Hoh Ranger Station		National Park Service - Air Resources Division	05/80
WA19	North Cascades NP-Marblemount Ranger Stn		US Geological Survey	02/84
WA21	La Grande		US Environmental Protection Agency-CAM	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	AMoN	National Park Service - Air Resources Division	10/99
West Virginia				
WV04	Babcock State Park		US Geological Survey	09/83
WV05	Cedar Creek State Park	AMoN	US Environmental Protection Agency-CAM	01/99
WV18	Parsons	AMoN	USDA Forest Service	07/78
Wisconsin				
WI08	Brule River	MDN	Wisconsin Department of Natural Resources	04/14
WI10	Potawatomi	MDN	Forest County Potawatomi Community	06/05
WI31	Devil's Lake	MDN	Wisconsin Department of Natural Resources	01/14
WI35	Perkinstown	AMoN	US Environmental Protection Agency-CAM	01/99
WI36	Trout Lake	MDN	Wisconsin Department of Natural Resources	01/80
WI37	Spooner		USDA Forest Service	06/80

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wyoming				
WY00	Snowy Range		USDA Forest Service	04/86
WY02	Sinks Canyon		Bureau of Land Management	08/84
WY06	Pinedale	AMoN	Bureau of Land Management	01/82
WY08	Yellowstone NP - Tower Falls	MDN	National Park Service - Air Resources Division	06/80
WY94	Grand Tetons National Park	AMoN	State of Wyoming DEQ	09/11
WY95	Brooklyn Lake	AMoN	USDA Forest Service	09/92
WY97	South Pass City		USDA Forest Service	04/85
WY98	Gypsum Creek		USDA Forest Service/Bridger Teton NF	12/84
WY99	Newcastle		Bureau of Land Management	08/81
Canada				
BC22	Haul Road Station		Rio Tinto	09/12
BC23	Lakelse Lake		Rio Tinto	03/13
BC24	Port Edward		Prince Rupert Port Authority	01/14
CAN5	Frelighsburg		US Geological Survey	10/01
SK20	Cactus Lake		Saskatchewan Ministry of Environment	02/12
SK21	Hudson Bay		Saskatchewan Ministry of Environment	04/12
SK30	Weyburn		Saskatchewan Ministry of Environment	06/16
SK31	Fox Valley		Saskatchewan Ministry of Environment	06/16

AIRMoN Map and Site Listings

National Atmospheric Deposition Program
Atmospheric Integrated Research Monitoring Network



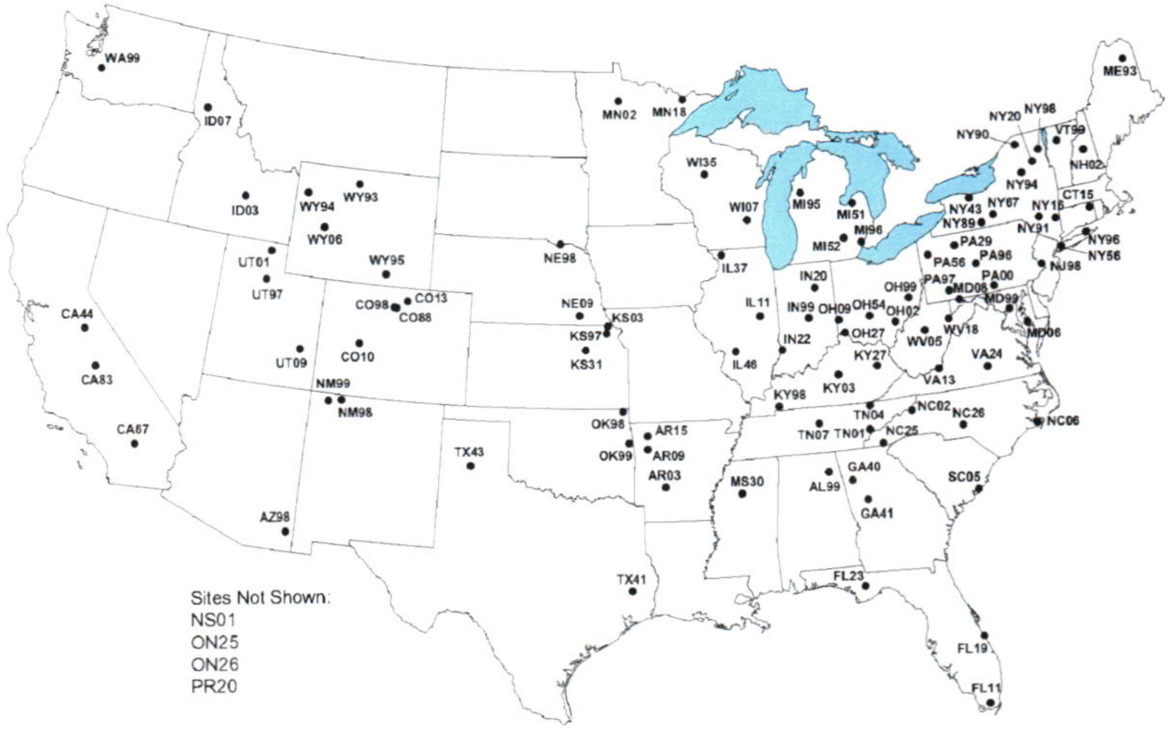
National Atmospheric Deposition Program/Atmospheric Integrated Research Monitoring Network Sites

July 31, 2016

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Delaware				
DE02	Lewes		NOAA-Air Resources Laboratory	09/92
Illinois				
IL11	Bondville	MDN/NTN/AMoN	NOAA-Air Resources Laboratory	10/92
New York				
NY67	Cornell University	AMoN	NOAA-Air Resources Laboratory	09/92
Pennsylvania				
PA15	Penn State	NTN	NOAA-Air Resources Laboratory	10/92
Tennessee				
TN00	Walker Branch Watershed		NOAA-Air Resources Laboratory	09/92
West Virginia				
WV99	Canaan Valley Institute		NOAA-Air Resources Laboratory	06/00

AMoN Map and Site Listings

National Atmospheric Deposition Program
Ammonia Monitoring Network



National Atmospheric Deposition Program/Ammonia Monitoring Network Sites

July 31, 2016

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL99	Sand Mountain Research & Ext. Center	NTN	US Environmental Protection Agency - CAM	03/11
Arizona				
AZ98	Chiricahua	NTN	National Park Service - Air Resources Division	03/11
Arkansas				
AR03	Caddo Valley	NTN	US Environmental Protection Agency - CAM	03/11
AR09	Rambo Hill		ARS-Agricultural Research Service	10/15
AR15	L C Farms		ARS-Agricultural Research Service	10/15
California				
CA44	Yosemite NP- Turtleback Dome		National Park Service - Air Resources Division	03/11
CA67	Joshua Tree NP - Black Rock	NTN	National Park Service - Air Resources Division	03/11
CA83	Sequoia NP-Ash Mountain		National Park Service - Air Resources Division	03/11
Colorado				
CO10	Gothic	NTN	US Environmental Protection Agency - CAM	09/12
CO13	Fort Collins		US Environmental Protection Agency - CAM	11/07
CO88	Rocky Mountain NP- Longs Peak		National Park Service - Air Resources Division	05/11
CO98	Rocky Mountain NP - Loch Vale	NTN	National Park Service - Air Resources Division	05/11
Connecticut				
CT15	Abington	NTN	US Environmental Protection Agency - CAM	03/11

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Florida				
FL11	Everglades NP - Research Center	NTN/MDN	National Park Service - Air Resources Division	03/11
FL19	Indian River		US Environmental Protection Agency - CAM	04/11
FL23	Sumatra	NTN	US Environmental Protection Agency - CAM	01/15
Georgia				
GA40	Yorkville	AMNet/MDN	Southern Company/ Atmospheric Research & Analysis	12/11
GA41	Georgia Station	NTN	US Environmental Protection Agency - CAM	06/11
Idaho				
ID03	Craters of the Moon NM	NTN	National Park Service - Air Resources Division	06/10
ID07	Nez Perce		US Environmental Protection Agency - CAM	12-15
Illinois				
IL11	Bondville	AIRMoN/MDN/ NTN	US Environmental Protection Agency - CAM	10/07
IL37	Stockton		US Environmental Protection Agency - CAM	04/11
IL46	Alhambra	NTN	US Environmental Protection Agency - CAM	03/11
Indiana				
IN20	Roush Lake	NTN	US Environmental Protection Agency - CAM	01/15
IN22	SW Purdue Ag Center	MDN	US Environmental Protection Agency - CAM	01/15
IN99	Indianapolis		US Environmental Protection Agency - CAM	10/07

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Kansas				
KS03	Reserve	MDN	Sac and Fox Nation of Missouri	10/11
KS31	Konza Prairie	NTN	US Environmental Protection Agency - CAM	03/11
KS97	Kickapoo Tribe - Powhattan	NTN	US Environmental Protection Agency - CAM	01/15
Kentucky				
KY03	Mackville	NTN	US Environmental Protection Agency - CAM	03/11
KY29	Crockett		US Environmental Protection Agency - CAM	01/15
KY98	Cadiz		US Environmental Protection Agency - CAM	03/11
Maine				
ME93	Ashland		US Environmental Protection Agency - CAM	01/15
Maryland				
MD06	Blackwater NWR		US Environmental Protection Agency - CAM	01/15
MD08	Piney Reservoir	MDN/AMNet/ NTN	State of MD/ Department of Natural Resources	08/10
MD99	Beltsville	MDN/AMNet/ NTN	State of MD/ Department of Natural Resources	08/10
Michigan				
MI51	Unionville	NTN	US Environmental Protection Agency - CAM	01/15
MI52	Ann Arbor	NTN/MDN	US Environmental Protection Agency - CAM	02/15
MI95	Hoxeyville		US Environmental Protection Agency - CAM	01/15
MI96	Detroit		US Environmental Protection Agency - CAM	10/07

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Minnesota				
MN02	Red Lake		US Environmental Protection Agency - CAM	01/15
MN18	Fernberg	NTN/MDN	US Environmental Protection Agency - CAM	10/07
Mississippi				
MS30	Coffeeville	NTN	US Environmental Protection Agency - CAM	01/15
Nebraska				
NE98	Santee	MDN	US Environmental Protection Agency - CAM	04/11
New Hampshire				
NH02	Hubbard Brook	NTN	US Environmental Protection Agency - CAM	06/12
New Jersey				
NJ98	Washington Crossing CASTNET		US Environmental Protection Agency - CAM	03/11
New Mexico				
NM98	Navajo Lake		US Environmental Protection Agency - CAM	01/08
NM99	Farmington		US Environmental Protection Agency - CAM	01/08
New York				
NY16	Cary Institute		Cary Institute Of Ecosystem Studies	10/09
NY20	Huntington Wildlife	MDN/AMNet/ NTN	US Environmental Protection Agency - CAM	06/12
NY43	Rochester	MDN/AMNet/ NTN	NYSERDA	06/16
NY56	Queens College		NYSERDA	06/16
NY67	Ithaca	AIRMoN	US Environmental Protection Agency - CAM	10/07

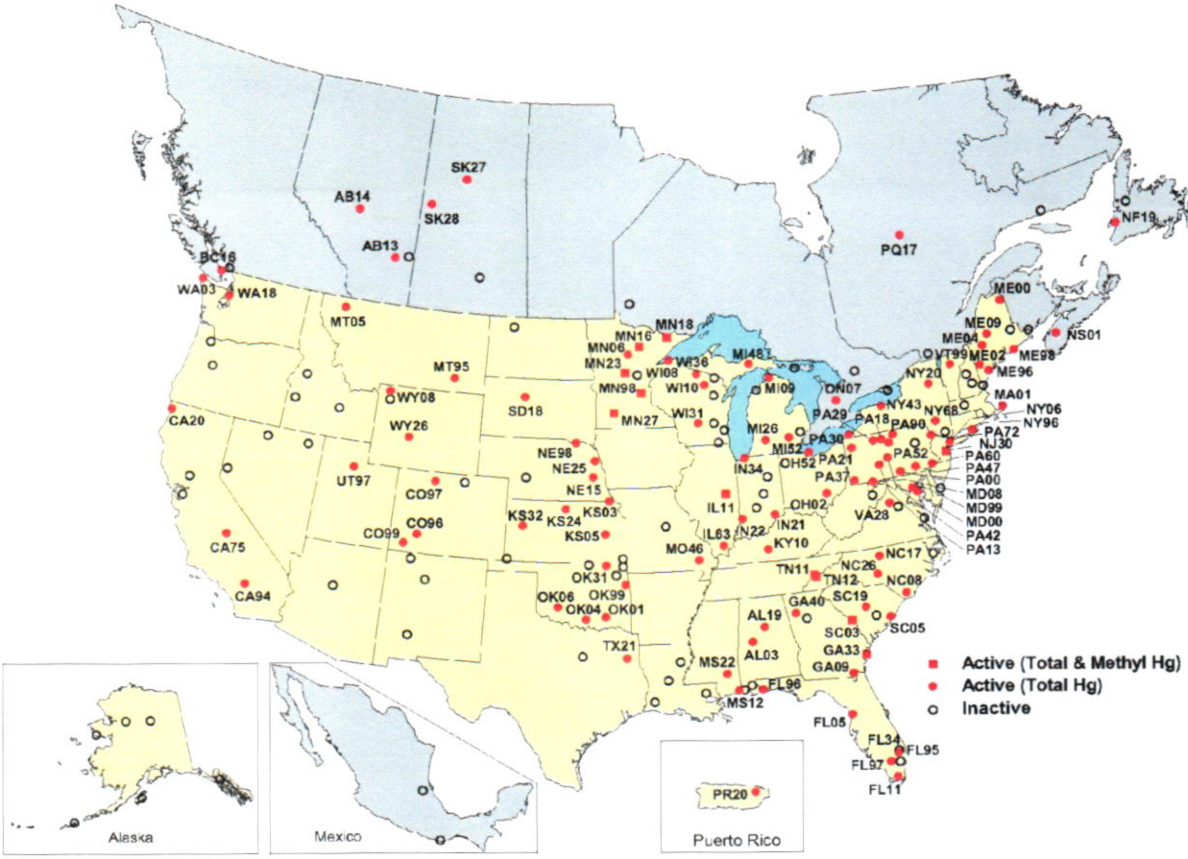
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
NY89	Pinnacle State Park		NYSERDA/NYSDEC	06/16
NY90	Potsdam-Clarkson University		NYSERDA	06/16
NY91	Claryville		US Environmental Protection Agency - CAM	01/15
NY94	Nick's Lake	NTN	US Environmental Protection Agency - CAM	11/12
NY96	Cedar Beach	NTN/MDN	County of Suffolk/Dept of Health Services - Peconic Estuary Program	08/14
NY98	Whiteface Mountain	NTN	US Environmental Protection Agency - CAM	11/12
North Carolina				
NC02	Cranberry		US Environmental Protection Agency - CAM	01/15
NC06	Beaufort	NTN	US Environmental Protection Agency - CAM	04/10
NC25	Coweeta	NTN	US Environmental Protection Agency - CAM	05/11
NC26	Candor	MDN	US Environmental Protection Agency - CAM	04/11
NC30	Duke Forest		US Environmental Protection Agency - CAM	06/08
NC35	Clinton Crops Research Station	NTN	US Environmental Protection Agency - CAM	08/08
Ohio				
OH02	Athens Super Site	AMNet/MDN	US Environmental Protection Agency - CAM	10/07
OH09	Oxford	NTN	US Environmental Protection Agency - CAM	01/15
OH27	Cincinnati		US Environmental Protection Agency - CAM	10/07
OH54	Deer Creek State Park	NTN	US Environmental Protection Agency - CAM	03/11
OH99	Quaker City		US Environmental Protection Agency - CAM	01/15
Oklahoma				
OK98	Quapaw		Quapaw Tribe of Oklahoma	10/15
OK99	Stilwell	MDN/AMNet	US Environmental Protection Agency - CAM	10/07

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Pennsylvania				
PA00	Arendtsville	NTN/MDN	US Environmental Protection Agency - CAM	10/09
PA29	Kane Experimental Forest	NTN/MDN	US Environmental Protection Agency - CAM	03/11
PA56	M.K. Goddard		US Environmental Protection Agency - CAM	12/14
PA96	Penn State - Fairbrook Park		US Environmental Protection Agency - CAM	01/15
PA97	Laurel Hill		US Environmental Protection Agency - CAM	07/15
Puerto Rico				
PR20	El Verde	MDN/NTN	U.S. Forest Service	03/14
South Carolina				
SC05	Cape Romain NWR	NTN/MDN	US Environmental Protection Agency - CAM	10/07
Tennessee				
TN01	Great Smoky Mountains NP- Look Rock		National Park Service - Air Resources Division	03/11
TN04	Speedwell	NTN	US Environmental Protection Agency - CAM	01/15
TN07	Edgar Evins		US Environmental Protection Agency - CAM	01/15
Texas				
TX41	Alabama- Coushatta		US Environmental Protection Agency - CAM	01/15
TX43	Cañónceta	NTN	US Environmental Protection Agency - CAM	10/07

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Utah				
UT01	Logan	NTN	State of Utah/DEQ	11/11
UT09	Canyonlands National Park-Island in the Sky	NTN	State of Utah	05/14
UT97	Salt Lake City	MDN/AMNet	State of Utah/DEQ	11/11
Vermont				
VT99	Underhill	MDN/NTN	US Environmental Protection Agency - CAM	11/12
Virginia				
VA13	Horton's Station	NTN	US Environmental Protection Agency - CAM	01/15
VA24	Prince Edward	NTN	US Environmental Protection Agency - CAM	03/11
Washington				
WA99	Mount Rainier NP - Tahoma Woods	NTN	National Park Service - Air Resources Division	03/11
West Virginia				
WV05	Cedar Creek State Park	NTN	US Environmental Protection Agency - CAM	01/15
WV18	Parsons	NTN	US Environmental Protection Agency - CAM	06/11
Wisconsin				
WI07	Horicon Marsh	AMNet	US Environmental Protection Agency - CAM	10/07
WI35	Perkinstown	NTN	US Environmental Protection Agency - CAM	03/11

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wyoming				
WY06	Pinedale	NTN	US Environmental Protection Agency - CAM	01/15
WY93	Basin - Big Horn		Air Resources Specialists, Inc.	06/15
WY94	Grand Tetons National Park	NTN	National Park Service - Air Resources Division	09/11
WY95	Brooklyn Lake	NTN	US Environmental Protection Agency - CAM	06/12
Canada				
NS01	Kejimkujik National Park	MDN/AMNet	Environment Canada	10/13
ON25	Bonner Lake		Environment Canada	10/13
ON26	Longwoods		Environment Canada	10/13

MDN Map and Site Listings



National Atmospheric Deposition Program/Mercury Deposition Network Sites

July 31, 2016

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL03	Centreville	NTN	Southern Company/Atmospheric Research and Analysis, In	06/00
AL19	Birmingham	NTN	Southern Company/Atmospheric Research and Analysis, In	12/10
Alaska				
AK06	Gates of the Arctic NP - Bettles	NTN	US Bureau of Land Management	11/08
California				
CA20	Yurok Tribe-Requa		Electric Power Research Institute	08/06
CA75	Sequoia NP-Giant Forest	NTN	National Park Service - Air Resources Division	07/03
CA94	Converse Flats	NTN	USDA Forest Service	04/06
Colorado				
CO96	Molas Pass	NTN	US Bureau of Land Management	06/09
CO97	Buffalo Pass - Summit Lake	NTN	USDA Forest Service	09/98
CO99	Mesa Verde NP-Chapin Mesa	NTN	National Park Service - Air Resources Division	12/01

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Florida				
FL05	Chassahowitzka NWR	NTN	US Fish & Wildlife Service - Chassahowitzka NWR	07/97
FL11	Everglades NP - Research Center	NTN/AMoN	South Florida Water Management District	03/96
FL95	Everglades -South Palm Beach County	NTN/AMoN	South Florida Water Management District	04/15
FL96	Pensacola	AMNet/NTN	Southern Company/Atmospheric Research and Analysis, In	12/10
FL97	Everglades - Western Broward County		South Florida Water Management District	11/06
Georgia				
GA09	Okefenokee NWR	NTN	US Fish & Wildlife Service - Air Quality Branch	07/97
GA33	Sapelo Island	NTN	Georgia Department of Natural Resources /Sapelo Island NERR	09/07
GA40	Yorkville	AMNet/AMoN	Southern Company/Atmospheric Research and Analysis, In	06/00
Illinois				
IL11	Bondville	AIRMoN/NTN/ AMoN	Illinois State Water Survey/NADP	01/99
IL63	Dixon Springs Agriculture Center	NTN	Lake Michigan Air Directors Consortium - LADCO	12/13
Indiana				
IN21	Clifty Falls State Park	AMNet	Lake Michigan Air Directors Consortium - LADCO	01/01
IN22	Southwest Purdue Agricultural Center	NTN/AMoN	Lake Michigan Air Directors Consortium - LADCO	12/13
IN34	Indiana Dunes National Lakeshore	NTN	Lake Michigan Air Directors Consortium - LADCO	10/00

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Kansas				
KS03	Reserve	AMoN	Kansas Department of Health and Environment	01/08
KS05	Coffey County Lake		Kansas Department of Health and Environment	12/08
KS24	Glen Elder State Park		Kansas Department of Health and Environment	05/08
KS32	Lake Scott State Park	NTN	Kansas Department of Health and Environment	06/08
Kentucky				
KY10	Mammoth Cave NP-Houchin Meadow	NTN	National Park Service - Air Resources Division	08/02
Maine				
ME00	Caribou	NTN	University of Maine	05/07
ME02	Bridgton	NTN	Maine Department of Environmental Protection/EPA	06/97
ME04	Carrabassett Valley	NTN	Penobscot Indian Nation/EPA	02/09
ME09	Greenville Station	NTN	Maine Department of Environmental Protection/EPA	09/96
ME96	Casco Bay - Wolfe's Neck Farm	NTN	Maine Department of Environmental Protection/EPA	01/98
ME98	Acadia NP - McFarland Hill	NTN	Maine Dept. of Environmental Protection/NPS-Acadia NP	03/96
Maryland				
MD00	Smithsonian Environmental Res Ctr		MD DNR/University of Maryland-Appalachian Lab	12/06
MD08	Piney Reservoir	NTN/AMNet/ AMoN	MD DNR/University of Maryland-Appalachian Lab	06/04
MD99	Beltsville	NTN/AMNet/ AMoN	MD DNR/University of Maryland-Appalachian Lab	06/04

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Massachusetts				
MA01	North Atlantic Coastal Lab	NTN	National Park Service - Air Resources Division	07/03
Michigan				
MI09	Douglas Lake	NTN/AMNet	Lake Michigan Air Directors Consortium - LADCO	12/13
MI26	Kellogg Biological Station	NTN	Lake Michigan Air Directors Consortium - LADCO	12/13
MI48	Seney NWR - Headquarters	NTN	US Fish & Wildlife Service-Air Quality Branch	11/03
MI52	Ann Arbor	NTN/AMoN	Lake Michigan Air Directors Consortium - LADCO	12/13
Minnesota				
MN06	Leech Lake		Leech Lake Band of Ojibwe	07/14
MN16	Marcell Experimental Forest	NTN	USDA Forest Service-North Central Research Station & Minnesota Pollution Control Agency	02/96
MN18	Fernberg	NTN/AMoN	Minnesota Pollution Control Agency	03/96
MN23	Camp Ripley	NTN	Minnesota Pollution Control Agency	07/96
MN27	Lamberton	NTN	Minnesota Pollution Control Agency	07/96
MN98	Blaine		Minnesota Pollution Control Agency	02/08
Mississippi				
MS12	Grand Bay NERR	NTN /AMNet	NOAA - Air Resources Lab	03/10
MS22	Oak Grove		Southern Company/Atmospheric Research and Analysis, Ir	06/00
Missouri				
MO46	Mingo NWR		US Fish & Wildlife Service - Air Quality Branch	03/02

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Montana				
MT05	Glacier NP - Fire Weather Station	NTN	National Park Service - Air Resources Division	10/03
MT95	Badger Peak		Northern Cheyenne Tribe	11/10
Nebraska				
NE15	Mead	NTN	Nebraska Department of Environmental Quality	06/07
NE25	Winnebago		Winnebago Tribe of Nebraska	11/09
NE98	Santee	AMoN	Santee Sioux Nation of Nebraska/EPA	10/13
New Jersey				
NJ30	New Brunswick	AMNet	State of New Jersey DEP	01/06
New York				
NY06	Bronx	AMNet/NTN	New York State Department of Env. Conservation	01/08
NY20	Huntington Wildlife	NTN/AMNet/ AMoN	NYSERDA	12/99
NY43	Rochester	NTN/AMNet	NYSERDA	01/08
NY68	Biscuit Brook	NTN	NYSERDA	03/04
NY96	Cedar Beach, Southhold	NTN/AMoN	NYSERDA	09/13

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
North Carolina				
NC08	Waccamaw State Park		North Carolina Dept. of Environment & Natural Resource	02/96
NC17	Greensboro	NTN	North Carolina A&T State University	01/15
NC26	Candor	AMoN	North Carolina Dept. of Environment & Natural Resource	11/05
Ohio				
OH02	Athens Super Site	AMNet/AMoN	Ohio Environmental Protection Agency	12/04
OH52	South Bass Island	AMNet	Ohio Environmental Protection Agency	05/14
Oklahoma				
OK01	McGee Creek		Oklahoma Department of Environmental Quality	10/06
OK04	Lake Murray		Oklahoma Department of Environmental Quality	10/07
OK06	Wichita Mountains NWR		Oklahoma Department of Environmental Quality	11/07
OK31	Copan		Oklahoma Department of Environmental Quality	10/06
OK99	Stilwell	AMNet/AMoN	Cherokee Nation/EPA	04/03
Pennsylvania				
PA00	Arendtsville	NTN/AMoN	PA Dept. of Env Protection/Penn State University	11/00
PA13	Allegheny Portage Railroad NHS	NTN	PA Dept. of Env Protection/Penn State University	01/97
PA18	Young Woman's Creek	NTN	PA Dept. of Env Protection/Penn State University	10/13
PA21	Goddard State Park	NTN	PA Dept. of Env Protection/Penn State University	03/10
PA29	Kane Experimental Forest	NTN/AMoN	PA Dept. of Env Protection/Penn State University	06/10
PA30	Erie	NTN	PA Dept. of Env Protection/Penn State University	06/00
PA37	Waynesburg		Electrical Power Research Institute	05/99
PA42	Leading Ridge	NTN	PA Dept. of Env Protection/Penn State University	03/10

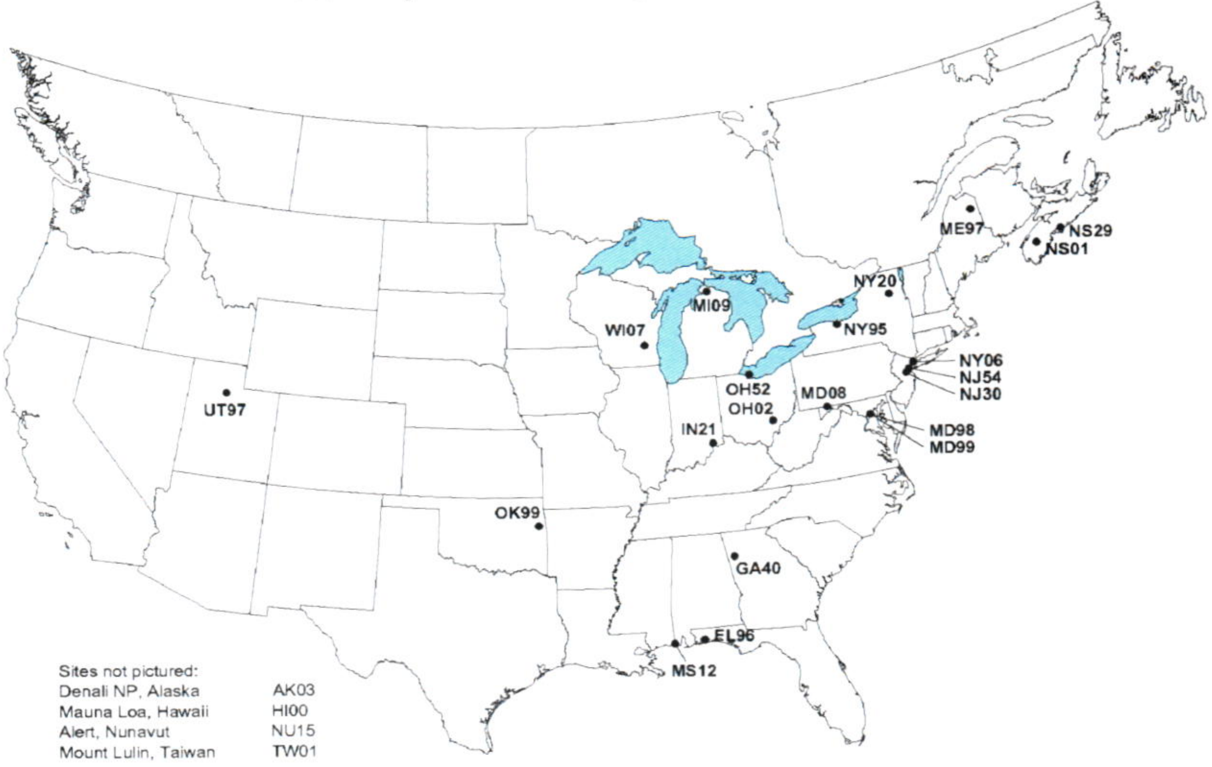
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
PA47	Millersville	NTN	PA Dept. of Env Protection/Penn State University	11/02
PA52	Little Pine State Park	NTN	PA Dept. of Env Protection/Penn State University	07/07
PA60	Valley Forge	NTN	PA Dept. of Env Protection/Penn State University	11/99
PA72	Milford	NTN	PA Dept. of Env Protection/Penn State University	09/00
PA90	Hills Creek State Park	NTN	PA Dept. of Env Protection/Penn State University	01/97
Puerto Rico				
PR20	El Verde	NTN/AMoN	US Geological Survey	08/14
South Carolina				
SC03	Savannah River	NTN	Savannah River Nuclear Solutions, LLC	01/01
SC05	Cape Romaine NWR	NTN/AMoN	US Fish & Wildlife Service - Air Quality Branch	03/04
SC19	Congaree Swamp		South Carolina Dept. of Health & Environmental Control	03/96
South Dakota				
SD18	Eagle Butte		Cheyenne River Sioux Tribe/EPA	03/07
Tennessee				
TN11	Great Smoky Mountains NP-Elkmont	NTN	National Park Service - Air Resources Division	01/02
TN12	Elkmont - Clingmans Dome		National Park Service - Great Smoky Mountains NP	04/15
Texas				
TX21	Longview	NTN	Texas Commission on Environmental Quality	03/96
Utah				
UT97	Salt Lake City	AMNet/AMoN	Utah Department of Environmental Quality	05/07
Vermont				
VT99	Underhill	NTN/AMoN	Vermont Monitoring Cooperative	07/04

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Virginia				
VA28	Shenandoah NP-Big Meadows	NTN	National Park Service - Air Resources Division	10/02
Washington				
WA03	Makah National Fish Hatchery		National Park Service - Air Resources Division	03/07
WA18	Seattle - NOAA		Illinois State Water Survey & Eurofins	03/96
Wisconsin				
WI08	Brule River	NTN	Wisconsin Department of Natural Resources	03/96
WI10	Potawatomi	NTN	Forest County Potawatomi Community/EPA	06/05
WI31	Devils Lake	NTN	Wisconsin Department of Natural Resources	01/01
WI36	Trout Lake	NTN	Wisconsin Department of Natural Resources	03/96
Wyoming				
WY08	Yellowstone NP-Tower Falls	NTN	Wyoming Department of Environmental Quality	10/04
WY26	Roundtop Mountain		State of Wyoming - DEQ	12/11

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
CANADA				
Alberta				
AB13	Henry Kroeger		ATCO Power Sheerness GS	09/04
AB14	Genesee		Jacques Whitford Stantec Axys Ltd.	07/06
British Columbia				
BC16	Saturna Island		Environment Canada	09/09
Newfoundland				
NF19	Stephenville		Environment Canada	2/10
Nova Scotia				
NS01	Kejimkujik NP	AMNet/AMoN	Environment Canada	07/96
Ontario				
ON07	Egbert		Environment Canada	03/00
Quebec				
PQ17	Chapais		Environment Canada	11/09
Saskatchewan				
SK27	Pinehouse		Environment Canada	05/15
SK28	Flat Valley		Environment Canada	02/16

AMNet Map and Site Listings

National Atmospheric Deposition Program
Atmospheric Mercury Network



National Atmospheric Deposition Program/Atmospheric Mercury Network Sites

July 31, 2016

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alaska				
AK03	Denali National Park	NTN	National Park Service - Air Resources Division	03/14
Florida				
FL96	Pensacola	MDN/NTN	Southern Company/Atmospheric Research & Analysis, Inc.	01/09
Georgia				
GA40	Yorkville	MDN/AMoN	Southern CompanyAtmospheric Research & Analysis, Inc.	01/09
Hawaii				
HI00	Mauna Loa		National Oceanic & Atmospheric Administration	12/10
Indiana				
IN21	Clifty Falls	MDN	Lake Michigan Air Director's Consortium (LADCO)	05/16
Maine				
ME97	Presque Isle		Aroostook Band of Micmacs	12/13

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Maryland				
MD08	Piney Reservoir	MDN/NTN/AMoN	State of Maryland	01/08
MD98	Beltsville II		NOAA/US Environmental Protection Agency-CAMD	01/07
MD99	Beltsville	MDN/NTN/AMoN	NOAA/US Environmental Protection Agency-CAMD	11/06
Michigan				
MI09	Douglas Lake	NTN/MDN	Lake Michigan Air Director's Consortium (LADCO)	08/15
Mississippi				
MS12	Grand Bay NERR	MDN/NTN	National Oceanic & Atmospheric Administration	09/06
New Jersey				
NJ30	New Brunswick	MDN	US Environmental Protection Agency - CAM	10/15
NJ54	Elizabeth Lab		US Environmental Protection Agency - CAM	10/15
New York				
NY06	New York City	MDN/NTN	State of New York	08/08
NY20	Huntington Wildlife Forest	MDN/NTN/AMoN	NYSERDA	11/07
NY43	Rochester B	MDN/NTN	State of New York	09/08
Ohio				
OH02	Athens Super Site	AMoN/MDN	Lake Michigan Air Directors Consortium	01/07
OH52	South Bass Island	MDN	Lake Michigan Air Directors Consortium	12/11
Utah				
UT97	Salt Lake City	MDN/AMoN	State of Utah	11/08

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wisconsin				
WI07	Horicon Marsh	AMoN	Lake Michigan Air Directors Consortium	01/11
Canada				
NS01	Kejimkujik NP	MDN/AMoN	Environment Canada	01/09
Taiwan				
TW01	Mt. Lunil		Taiwan EPA	01/10

Proceedings Notes

The National Atmospheric Deposition Program (NADP) was established in 1977 under State Agricultural Experiment Station (SAES) leadership to address the problem of atmospheric deposition and its effects on agricultural crops, forests, rangelands, surface waters, and other natural and cultural resources. In 1978, sites in the NADP precipitation chemistry network first began collecting one-week, wet-only deposition samples for analysis at the Illinois State Water Survey's Central Analytical Laboratory (CAL), located at the University of Illinois, Urbana-Champaign. The network was established to provide data on amounts, temporal trends, and geographic distributions of the atmospheric deposition of acids, nutrients, and base cations by precipitation.

Initially, the NADP was organized as SAES North Central Regional Project NC-141, which all four SAES regions further endorsed in 1982 as Interregional Project IR-7. A decade later, IR-7 was reclassified as National Research Support Project No. 3 (NRSP-3), which it remains. NRSP projects are multistate activities that support research on topics of concern to more than one state or region of the country. Multistate projects involve the SAES in partnership with the USDA National Institute of Food and Agriculture and other universities, institutions, and agencies.

In October 1981, the federally supported National Acid Precipitation Assessment Program (NAPAP) was established to increase understanding of the causes and effects of acidic precipitation. This program sought to establish a long-term precipitation chemistry network of sampling sites distant from point source influences. Because of its experience in organizing and operating a national-scale network, the NADP agreed to coordinate operation of NAPAP's National Trends Network (NTN). To benefit from identical siting criteria and operating procedures and a shared analytical laboratory, NADP and NTN merged with the designation NADP/NTN. This merger brought substantial new federal agency participation into the program. Many NADP/NTN sites were supported by the USGS, NAPAP's lead federal agency for deposition monitoring.

In October 1992, the Atmospheric Integrated Research Monitoring Network (AIRMoN) joined the NADP. AIRMoN sites collect samples daily when precipitation occurs. In January 1996, the NADP established the Mercury Deposition Network (MDN), the third network in the organization. The MDN was formed to provide data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors. In October 2009, the Atmospheric Mercury Network (AMNet) joined the NADP as the fourth network. AMNet measures the concentration of atmospheric mercury. In October 2010, the Ammonia Monitoring Network (AMoN) joined the NADP, measuring atmospheric ammonia concentrations using passive monitors.

SAES project NRSP-3 was renewed in 2014 and it continues to offer a unique opportunity for cooperation among scientists from land-grant and other universities, government agencies, and non-governmental organizations. It provides a framework for leveraging the resources of nearly 100 different sponsoring agencies to address contemporary and emerging issues of national importance.

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