



**2012 Annual Meeting and Scientific Symposium**  
**The NADP Cooperative: State, Local and Tribal Perspectives**

**October 2-5, 2012**  
**Portland, ME**



National Atmospheric Deposition Program

## Schedule at a Glance

	Monday October 1	Tuesday October 2	Wednesday October 3	Thursday October 4	Friday October 5
7:30	Registration	Registration	Registration	Registration	
7:45					
8:00	Operator's Training Course NTN & MDN	Registration	Registration	Registration	
8:15					
8:30		Joint Subcommittee Meeting	Conference Opening	Remarks	Field Trip/TDEP
8:45			Annual State of NADP	Session 6 (5 Speakers)	
9:00					
9:15					
9:30					
9:45		Break	Break		
10:00		Subcommittee Meetings (4)	Session 1 (4 Speakers)	Break	
10:15				Session 6 (cont) (2 speakers)	
10:30				Session 7 (6 Speakers)	
10:45					
11:00			Session 2 (4 Speakers)		
11:15					
11:30					
11:45					
12:00					
12:15	Lunch	Lunch on your own	Lunch on your own	Lunch on your own	
12:30					
12:45					
1:00					
1:15					
1:30	Operator's Training Course NTN & MDN	Joint Subcommittee meeting	Session 3 (7 Speakers)	Session 8 (5 Speakers)	
1:45					
2:00					
2:15					
2:30					
2:45					
3:00				Break	
3:15				Session 8 cont. (3 Speakers)	
3:30		Break	Session 4 (3 Speakers)		
3:45		Executive Committee Meeting		Closing	
4:00			Session 5 (2 speakers)		
4:15					
4:30					
4:45					
5:00			Break		
5:15					
5:30			Poster Session and Reception		
5:45					
6:00		Break			
6:15					
6:30					
7:00		Sub Committee on Urban Atmospheric Monitoring			
7:45					
8:00					
9:00					

**NADP 2012  
Technical Committee Meeting**

October 2-5, 2012  
Portland, ME

**Scientific Symposium Chair**  
Andrew Johnson  
Maine Department of Environmental Protection

**PROCEEDINGS**

Prepared by

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Prairie Research Institute  
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**October 2012**

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## **NADP Scientific Symposium Agenda**



**NADP Annual Meeting and Scientific Symposium  
South Portland, ME  
October 2-5, 2012**

<b>Tuesday, October 2, 2012</b>		<b>Room Location</b>
Open All Day	Registration Desk	West Foyer
8:30 a.m. – 9:45 a.m.	Joint Subcommittee Meeting	Lighthouse A
9:45 a.m. – 10:00 a.m.	Break	West Foyer
10:00 a.m. – 12:00 noon	Subcommittee Meetings Network Operations Data Management & Analysis Ecological Response and Outreach Critical Loads	Lighthouse A Breakwater Monhegan Whaleback
12:00 noon - 1:30 p.m.	Lunch - On your own	
1:30 p.m. – 3:30 p.m.	Joint Subcommittee Meeting FOCUS (meets until 4:00 p.m.)	Lighthouse A Monhegan
3:30 p.m. - 3:45 p.m.	Break	West Foyer
3:45 p.m. - 6:00 p.m.	Executive Committee Meeting	Lighthouse B
6:00 p.m. – 7:00 p.m.	Dinner on your own	
7:00 p.m. – 9:00 p.m.	Sub Committee on Urban Atmospheric Monitoring	Monhegan

<b>Wednesday, October 3, 2012</b>		<b>Room Location</b>
Open All Day	Registration/Office	West Foyer
8:30 a.m. - 9:30 a.m.	<b>Welcome, Program Office Report Awards and Announcements</b> Andy Johnson: NADP Vice Chair, Symposium Chair Maine DEP, Bureau of Air Quality David Gay: NADP Coordinator Kathleen Weathers: NADP Chair Cary Institute of Ecosystem Studies	Lighthouse Ballroom

<b>Wednesday, October 3, 2011</b>		<b>Room Location</b>
9:30 a.m. – 10:00 a.m.	Break	Lighthouse Ballroom
<b>Technical Session 1:</b>	<b>Acidic Deposition</b> Session Chair: Richard Grant, Purdue University	
10:00 a.m. – 10:15 a.m.	<b>Early Indications of Soil Recovery from Acidic Deposition in U.S. Red Spruce Forests</b> Gregory B. Lawrence, U.S. Geological Survey	
10:15 a.m. – 10:30 a.m.	<b>Simulating the response of eight forested lake-watersheds in the Adirondacks region of New York to acid deposition</b> Habibollah Fakhrai, Syracuse University	
10:30 a.m. – 10:45 a.m.	<b>Recovery from chronic and snowmelt seasonal acidification at the Hubbard Brook Experimental Forest: Long-term trends in stream and soil water chemistry</b> Colin B. Fuss, Syracuse University	
10:45 a.m. – 11:00 a.m.	<b>Stream Chemistry and Sensitivity to Acid Deposition along the Appalachian Trail</b> Doug Burns, U.S. Geological Survey	
<b>Technical Session 2:</b>	<b>Critical Load</b> Session Chair: Greg Lampman, NYSERDA	
11:00 a.m. – 11:15 a.m.	<b>Comparison of surface water critical loads of acidity with modeled and measured deposition in the United States</b> Krish Vijayaraghavan, ENVIRON International Corporation	
11:15 a.m. – 11:30 a.m.	<b>Critical Loads Approach to Ecosystem Services</b> Tim Sullivan, E&S Environmental Chemistry, Inc.	
11:30 a.m. – 11:45 a.m.	<b>Refining empirical critical loads for nutrient nitrogen: Northeastern pilot study.</b> Claire O’Dea, US Forest Service	

Wednesday, October 3, 2012		Room Location
		Lighthouse Ballroom
<b>Technical Session 2:</b>	<b>Critical Load (continued)</b> Session Chair: Greg Lampman, NYSERDA	
11:45 a.m. – 12:00 p.m.	<b>Critical thresholds of atmospheric deposition in view of changing climatic conditions</b> Salim Belyazid, BCC-AB, Sweden	
12:00 p.m. – 1:30 p.m.	Lunch on your own	
<b>Technical Session 3:</b>	<b>Urban Atmospheric Deposition</b> Session Chair: Rich Pouyat, USDA Forest Service	
1:30 p.m. – 1:45 p.m.	<b>MercNet: A National Mercury Monitoring Network</b> David Evers,	
1:45 p.m. – 2:00 p.m.	<b>CMAQ estimates of deposition to urban area in the US: Current approaches and future challenges</b> Donna B. Schwede, US Environmental Protection Agency	
2:00 p.m. – 2:15 p.m.	<b>Pattern and Process in Atmospheric Deposition in Heterogeneous Urban Environments</b> Tom H. Whitlow, Cornell University	
2:15 p.m. – 2:30 p.m.	<b>Assessing urban influences on ecosystems and the atmospheric</b> Lucy Hutyra, Boston University	
2:30 p.m. – 2:45 p.m.	<b>Effects of urbanization and tree species composition on nitrogen deposition and leaching</b> Pamela Templer, Boston University	
2:45 p.m. – 3:00 p.m.	<b>Atmospheric nitrogen deposition in arid Phoenix, Arizona is lower than expected: Findings from a methods comparison</b> Elizabeth M. Cook, Arizona State University	
3:00 p.m. – 3:15 p.m.	Hom	
3:15 p.m. – 3:30 p.m.	Break	

Wednesday, October 3, 2012		Room Location
		Lighthouse Ballroom
<b>Technical Session 4:</b>	<b>Agriculture/Ammonia</b> Session Chair: Wayne Robarge North Carolina State University	
3:30 p.m. – 3:45 p.m.	<b>An improved high-spatial resolution inventory for ammonia emissions from agricultural fertilization</b> Srinidhi Balasubramanian, University of Illinois	
3:45 p.m. – 4:00 p.m.	<b>Ammonia emissions from hog farrow-to-wean waste lagoons</b> Richard H. Grant, Purdue University	
4:00 p.m. – 4:15 p.m.	<b>Utilizing the nitrogen isotopic composition of ammonia to investigate regional transport of ammonia emissions: <math>\delta^{15}\text{N-NH}_3</math> values at AMoN sites</b> J. David Felix, University of Pittsburgh	
<b>Technical Session 5:</b>	<b>Better Measurements and Techniques</b> Session Chair: Dirk Felton	
4:15 p.m. – 4:30 p.m.	<b>Development of the Next Generation of Flux Measurement Tools</b> Berkley B. Almand, University of Colorado	
4:30 p.m. – 4:45 p.m.	<b>Using measurements and model simulations to understand the cause of the seasonal variation in the oxygen isotopic composition of precipitation along the western US coast</b> Nikolaus H. Buening, University of Southern California	
4:45 p.m. – 5:30 p.m.	Break	
5:30 p.m. – 8:00 p.m.	<b>Poster Session and Reception</b>	West Foyer/Sebago
<b>Thursday, October 4, 2012</b>		<b>Room Location</b>
Open All Day	Registration/Office	Registration/Office

Thursday, October 4, 2012

Room Location

Lighthouse Ballroom

- 8:30 a.m. – 8:45 a.m. **Opening remarks, announcements and overview of Day 2**  
Andy Johnson, NADP Vice Chair,  
Maine DEP, Bureau of Air Quality
- Technical Session 6: Nitrogen Deposition**  
Session Chair: Bill Thompson  
Penobscot Indian Nation
- 8:45 a.m. – 9:00 a.m. **Chemical Transport Modeling of Nitrogen Deposition in the Western U.S.: A National Park Perspective**  
Michael Bama, National Park Service
- 9:00 a.m. – 9:15 a.m. **Nutrient Criteria Development for Sierra Nevada Lakes**  
Andrea Heard, University of California, Riverside and National Park Service
- 9:15 a.m. – 9:30 a.m. **Initial Findings from GrandTREnds: The Grand Teton Reactive Nitrogen Deposition Study**  
J. L. Collett, Colorado State University
- 9:30 a.m. – 9:45 a.m. **Application of USEPA's Watershed Deposition Tool to Estimate Atmospheric Deposition of Nitrogen to the Indian River Basin, Florida**  
Noreen D. Poor, Kivmetrics, LLC
- 9:45 a.m. – 10:00 a.m. **Using National Trends Network Data to Assess Nitrogen Deposition in a Near-Coastal Environment: Marine Corp Base Camp Lejeune (MCBCL), Jacksonville, NC**  
Wayne P. Robarge, North Carolina State University
- 10:00 a.m. – 10:15 a.m. Break
- Technical Session 6: Nitrogen Deposition (cont)**  
Session Chair: Bill Thompson  
Penobscot Indian Nation
- 10:15 a.m. – 10:30 a.m. **State-Level Oxidized Nitrogen Source Attribution from CMAQ for the Chesapeake Bay TMDL Process to Support Air-Water Trading**  
Robin Dennis, U.S. Environmental Protection Agency

Thursday, October 4, 2012

Room Location

Lighthouse Ballroom

- 10:30 a.m. – 10:45 a.m. **Examination of Aquatic Acidification Index (AAI) component variability and implications for characterizing atmospheric and biogeochemical nitrogen processes.**  
Richard Scheffe, U.S. Environmental Protection Agency
- Technical Session 7: Understanding Total Deposition of Nitrogen & Sulfur**  
Session Chair: Tom Butler  
Cornell University
- 10:45 a.m. – 11:00 a.m. **New York's plan to enhance the pilot monitoring project to inform the next review of the secondary standards for oxides of nitrogen and sulfur**  
Greg Lampman, New York State Energy Research and Development Authority
- 11:00 a.m. – 11:15 a.m. **Transference Ratios to Predict Total Oxidized Sulfur and Nitrogen Deposition**  
Joseph Sickles, US EPA
- 11:15 a.m. – 11:30 a.m. **Evaluation and Variability of Chemical Transport Models Sulfur and Nitrogen Compound Deposition and Ambient Concentration Estimates**  
Eladio Knipping, Electric Power Research Institute (EPRI)
- 11:30 a.m. – 11:45 a.m. **Measurement of air-surface exchange of speciated nitrogen and sulfur compounds using a modified MARGA 2S: Assessment and control of data quality**  
Ian C. Rumsey, U.S. Environmental Protection Agency
- 11:45 a.m. – 12:00 p.m. **Measurement of air-surface exchange of speciated nitrogen and sulfur compounds using a modified MARGA 2S: Concentrations and fluxes above a grass field**  
John T. Walker, U.S. Environmental Protection Agency
- 12:00 p.m. – 12:15 p.m. **Assessment of Long-term Monitoring of Nitrogen, Sulfur, and Mercury Deposition and Environmental Effects in New York State**  
Carrie R. Levine, SUNY College of Environmental Science and Forestry
- 12:15 p.m. – 1:45 p.m. Lunch on your own

Thursday, October 4, 2012

Room Location

Lighthouse Ballroom

- Technical Session 8: Mercury**  
Session Chair: Barry Mower  
Maine DEP
- 1:45 p.m. – 2:00 p.m. **Mercury wet deposition to a remote island in the west Pacific Ocean and a high-elevation site in central Taiwan**  
Guey-Rong Sheu, National Central University
- 2:00 p.m. – 2:15 p.m. **RAMIX - A Step towards Understanding Atmospheric Mercury Chemistry and Tekran® Observations**  
Mae Sexauer Gustin, University of Nevada-Reno
- 2:15 p.m. – 2:30 p.m. **A novel approach: Using financial market technical indicators to assess temporal trends in mercury deposition and concentrations**  
Arnout ter Schure, Electric Power Research Institute
- 2:30 p.m. – 2:45 p.m. **Investigating sources of gaseous oxidized mercury in dry deposition at three sites across Florida, USA**  
Mae Sexauer Gustin, University of Nevada - Reno
- 2:45 p.m. – 3:00 p.m. **Comparing 6 years of event-based rainfall deposition of mercury, trace metals, and major ions collected close to a coal-fired power plant with nearby NADP/MDN sites.**  
Arnout ter Schure, Electric Power Research Institute
- 3:00 p.m. – 3:15 p.m. Break
- Technical Session 8: Mercury (continued)**  
Session Chair: Barry Mower  
Maine DEP
- 3:15 p.m. – 3:30 p.m. **Aquatic Mercury Assessment of the Savannah River Site**  
Dennis G. Jackson, Savannah River National Laboratory
- 3:30 p.m. – 3:45 p.m. **Seasonal variation in pathways of atmosphere-land exchange of mercury in a northern hardwood forest**  
Xuying Wang, Syracuse University
- 3:45 p.m. – 4:00 p.m. **Recent progress on mercury deposition studies**  
Leiming Zhang, Environment Canada
- 4:00 p.m. – 4:15 p.m. **Closing Comments**

Friday, October 5, 2012

**Scientific Tour - Wolf Neck State Park, Freeport and Bradbury Mountain State Park**

- 9:00 a.m. - Depart from hotel
- 9:45 a.m. - Arrive at Wolf Neck State Park  
(Hiking, visit to ME96, etc.)
- 11:45 a.m. - Meet to depart for downtown Freeport  
(Lunch on your own)
- 1:45 p.m. - Meet to depart for Bradbury Mountain State Park or explore downtown Freeport
- 3:45 p.m. - Meet to return to Freeport to pick up non-hikers and return to hotel



OR

8:30 a.m. - 2:00 p.m. **Total Deposition Science Committee**

## 2012 NADP SITE OPERATOR AWARDS

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# NATIONAL ATMOSPHERIC DEPOSITION PROGRAM OPERATOR AWARDS

## 5 YEAR AWARDS

Site	Operator Name	Site Name	Wet Start	Agency
AB13 - MDN	Tom Hansen	Henry Kroeger	09/21/04	ATCO Power
GA33 - MDN	Aimee Gaddis	Sapelo Island	09/25/07	GA-DNR
KY03 - NTN	Belinda Warden	Mackville	11/29/83	U.S. Geological Survey
OK04 - MDN	Jeff Davidson	Lake Murray	10/30/07	Oklahoma DEQ
PA52 - NTN	Kevin Homer	Little Pine State Park	07/31/07	Pennsylvania DEP
UT08 - NTN	Christina Bodey	Murphy Ridge	03/25/86	Wyoming DEQ
VI01 - NTN	Devon Tyson	Virgin Islands NP - Lind Park	04/14/98	National Park Service-ARD
WV05 - NTN	Heidi Lindsay	Cedar Creek State Park	01/26/99	U.S. EPA-Clean Air Markets
WV99 - MDN AIRMoN	Julie Dzaack	Canaan Valley Institute Canaan Valley Institute	06/26/07 06/01/00	NOAA
WY08 - MDN	John Klapotosky	Yellowstone National Park-Tower Falls	10/21/04	Wyoming DEQ

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## 10 Year Awards

Site	Operator Name	Site Name	Wet Start	Agency
GA33- NTN	Aimee Gaddis	Sapelo Island	11/26/02	GA DNR/UGA
KY10 - NTN	Johnathan Jernigan	Mammoth Cave NP-Houchin Meadow	08/27/02	National Park Service-ARD
MT97 - NTN	Tanya Neidhardt	Lost Trail Pass	09/25/90	U.S. Forest Service
NC29 - NTN	Joe Jarman	Hoffman Forest	07/02/02	NC State University
SD04 - NTN	Marc Ohms	Wind Cave NP-Elk Mountain	11/05/02	National Park Service-ARD
VA99 - NTN	Ken Hickman	Natural Bridge Station	07/02/02	U.S. Forest Service
WI36 - NTN	Therese Hubacher	Trout Lake	01/22/80	Wisconsin DNR

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## 15 Year Awards

Site	Operator Name	Site Name	Wet Start	Agency
GA09 - MDN	Ronald Phernetton	Okefenokee National Wildlife Refuge	07/29/97	U.S. Fish & Wildlife Service
ME02 - MDN	Peter Lowell	Bridgton	06/03/97	Maine DEP
MN08 - NTN	Mary Jo Flack	Hovland	12/31/96	Minnesota PCA
NC36 - NTN	Paul Anderson	Jordan Creek	10/18/83	U.S. Geological Survey
VT99 - NTN	Miriam Pendleton	Underhill	06/12/84	University of Vermont
	AIRMoN		01/27/93	
WI99 - MDN	Ted Peters	Lake Geneva	01/07/97	Wisconsin DNR

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## 20 Year Awards

Site	Operator Name	Site Name	Wet Start	Agency
AK03 - NTN	Andrea Blakesley	Denali NP- Mt. McKinley	06/17/80	National Park Service-ARD
IL11 - AIRMoN	Michael Snider	Bondville	10/01/92	NOAA- ARL
MA08 - NTN	Daniel Pepin	Quabbin Reservoir	03/05/82	NESCAUM
NY67 - AIRMoN	Tom Butler	Ithaca	09/30/92	NOAA-ARL
WY99 - NTN	Rod Randall	Newcastle	08/11/81	BLM

25 Year Awards

Site	Operator Name	Site Name	Wet Start	Agency
FL41 - NTN	April Ammeson	Verna Well Field	08/25/83	U.S. Geological Survey
KS31 - NTN	Rosemary Ramundo	Kenza Prairie	08/17/82	SAES-Kansas State University
KY22 - NTN	Robert Watts	Lilley Cornert Woods	09/06/83	U.S. Geological Survey
MT00 - NTN	Les Frickle	Little Bighorn Battlefield National Monument	07/13/84	U.S. Geological Survey
NC25 - NTN	Robert McCollum	Coweeta	07/05/78	U.S. Forest Service



**TECHNICAL SESSION 1:  
ACIDIC DEPOSITION**

*Session Chair: Richard Grant,  
Purdue University*

## Early Indications of Soil Recovery from Acidic Deposition in U.S. Red Spruce Forests

Lawrence, G.B.<sup>1</sup>, Shortle, W.C.<sup>2</sup>, David, M.B.<sup>3</sup>, Smith, K.T.<sup>2</sup>, Warby, Raf<sup>4</sup>, and Lapenis, A.G.<sup>5</sup>

Forty to fifty percent decreases in acidic deposition through the 1980s and 90s led to partial recovery of acidified surface waters in the northeastern United States. However, the limited number of studies that have assessed soil change found increased soil acidification during this period. To evaluate possible changes in soils through the 1990s, soils in six red spruce stands in NY, VT, NH, and ME, first sampled in 1992-1993, were resampled in 2003-2004. There were no indications of recovery in the upper 10 cm of the B horizon, but Oa-horizon pH was higher at three sites at  $p < 0.01$ , higher at one site at  $p < 0.1$ , and lower ( $p < 0.05$ ) at the NY site. The increase in pH is likely to be tied to decreases in organic carbon concentrations ( $p < 0.05$ ) that occurred at each of the sites where pH increased (Table 1). The cause of the decrease in organic carbon concentrations is uncertain, but may be related to decreased acidic deposition as well as increased temperature and precipitation that occurred at these sites. The strongest indication of recovery was a decrease in exchangeable Al concentrations in Oa horizons ( $p < 0.05$ ) of 20% to 40% at all sites except NY. However, Ca concentrations did not change except for an increase ( $p < 0.05$ ) at Kossuth ME. The Al decrease can be attributed to decreased deposition of  $SO_4^{2-}$ , which decreased the mobility of Al throughout the upper soil profile. Decreased mobilization of Al within the B horizon lowered hydrologic inputs of Al into the Oa horizon, and as the Oa decomposed and was replaced by organic matter from the Oe, exchangeable Al concentrations in the Oa horizon were further lowered. These data are the first indications in North America of soil recovery from the declining trend in acidic deposition. However, an increase in availability of Ca in the mineral soil from decreased leaching was not apparent. Results indicate a nascent recovery in the Oa horizon driven largely by vegetative processes.

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## Simulating the response of eight forested lake-watersheds in the Adirondacks region of New York to acid deposition

Habibollah Fakhraei\*, Charles T. Driscoll\*\*

In this study the model PnET-BGC was applied to eight drainage lakes in the Adirondack region of New York to assess the response of soil and surface waters to change in atmospheric deposition. The eight lakes are located throughout the Adirondack Park and monitored through Adirondacks Long Term Monitoring program (ALTM). The lakes studied are Brook Trout Lake, Constable Pond, Grass Pond, Middle Branch Pond, Middle Settlement Pond, Squash Pond, West Pond, and East Copperas Pond. All lakes except Grass Pond (which classified as medium till and moderately sensitive to acidification) have thin deposits of glacial till and are sensitive to acidification. Squash and East ponds have high dissolved organic carbon, but the others have low DOC. The model-simulated monthly and annual volume-weighted concentrations of the major solutes indicated that model simulations responded well to changes in atmospheric deposition and captured the trends of measured water chemistry at all eight sites. A sensitivity analysis was performed on Brook Trout Lake to assess the sensitivity of major state variables in response to change in Al weathering rate and water holding capacity (WHC). The result indicated that model predictions of inorganic monomeric aluminum, organic aluminum and base saturation were highly sensitive to variations in Al weathering rate. Sensitivity analysis also showed decrease in ANC and  $NO_3^-$  and increase in Mg and soil base saturation in response to increase WHC.

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## Recovery from chronic and snowmelt seasonal acidification at the Hubbard Brook Experimental Forest: Long-term trends in stream and soil water chemistry

Colin B. Fuss\*, Charles T. Driscoll\*\*

We investigated long-term chemistry trends in stream water (1982-2011) and soil water (1984-2011) along an elevation gradient to evaluate the progress of recovery of these drainage waters from chronic acidic deposition at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire, USA. Deposition of sulfate and nitrate has declined throughout the study period due to controls on emissions from electric utilities. Decreases in the concentrations of acid anions have decreased the leaching of base cations from the soil. Stream water pH has increased at a rate of 0.01 units yr<sup>-1</sup> and the acid neutralizing capacity (ANC) has gained 0.69  $\mu\text{eq l}^{-1}$  yr<sup>-1</sup>. While the changes in stream water chemistry broadly reflect changes in soil water chemistry, we found variation by landscape position in the magnitude and significance of changes in the chemistry of soil water draining the organic (Oa) and mineral (Bs) soil horizons. Snowmelt waters are generally characterized by the lowest ANC values during the annual cycle. To test whether the episodic acidification associate with spring snowmelt is improving along with the rest of the annual cycle, we analyzed the data from the samplings representing the peak snowmelt period for comparison with the overall record. Stream water during the snowmelt period has had very similar gains in ANC as for the overall time series (0.69 and 0.78  $\mu\text{eq l}^{-1}$  yr<sup>-1</sup>, respectively). Additionally, we found that for both the overall stream chemistry record and for the snowmelt period, the trends showed similar increases in pH, decreases in sulfate, and decreases in nitrate. The similarity between the overall time series and the snowmelt periods is an important finding that demonstrates the recovery from chronic acidification of drainage waters that travels via shallow flowpaths as well as the deeper mineral soil flowpaths that contribute to stream baseflow. This finding indicates that episodic acidification associated with snowmelt is declining in severity.

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## Stream Chemistry and Sensitivity to Acid Deposition along the Appalachian Trail

Douglas A. Burns<sup>1</sup>, Karen C. Rice<sup>2</sup>, Gregory B. Lawrence<sup>3</sup>, Timothy J. Sullivan<sup>4</sup>, Alan C. Ellsworth<sup>5</sup>

The Appalachian Trail (AT) and its corridor of protected land (minimum of 1.6 km on either side of the trail) stretches for 3,515 km from Maine to Georgia, and includes several regions that are among the most acid sensitive landscapes in the US. A study funded by the National Park Service, is evaluating the effects of atmospheric deposition on forested ecosystems along the AT through collection, analysis, and modeling of data from streams, soils, and vegetation. More than 250 headwater streams along the AT corridor were sampled twice during 2010-12 with a goal of targeting high and low flow at each stream. Overall, 69% of the stream samples had an acid-neutralizing capacity (ANC) less than 100 microequivalents per liter (meq/L). These relatively low ANC stream values likely reflect several factors, including high levels of acid deposition, steep slopes that produce rapid runoff, and slow mineral weathering rates that provide limited neutralization of acid deposition. However, there was a wide range of ANC values among the streams (-54 to 1717 meq/L), a reflection of wide variation in the above mentioned factors. Streams in the northern half (north of the MD-PA border) of the AT (median ANC = 21 meq/L) were more acidic than those in the southern half (median ANC = 70 meq/L). Furthermore, 20% of the northern AT streams had inorganic monomeric aluminum concentrations greater than 2.5 micromoles per liter (mmol/L), an indicator of stress in sensitive aquatic biota, whereas only 2% of southern AT streams exceeded this value. Streams in New Hampshire and Pennsylvania had low median ANC values of 10 meq/L and 19 meq/L, respectively, consistent with previous stream studies in these states. Streams in Georgia, an area where stream acidification is not well known and has not been widely studied, had the lowest median ANC value of 38 meq/L among the southern AT states. Streams in Massachusetts and Connecticut, another area not well known for acidified surface waters, had a low median ANC value of 13 meq/L. Future work will explore the relations among these stream chemistry data and various landscape and geochemical metrics believed to be most strongly related to acid-base status with an aim of providing a spatial model of stream chemistry for the entire AT. These modeled data will be compared to modeled acid deposition to evaluate the relative amount of the AT corridor landscape relative to critical loads of sulfur and nitrogen deposition that are affecting aquatic ecological resources.

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<sup>3</sup>Gregory B. Lawrence, U.S. Geological Survey, Troy, NY

<sup>4</sup>Timothy J. Sullivan, E&S Environmental Chemistry, Corvallis, OR

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**TECHNICAL SESSION 2:  
CRITICAL LOAD**

*Session Chair: Greg Lampman,  
NYSERDA*

## Comparison of surface water critical loads of acidity with modeled and measured deposition in the United States

Krish Vijayaraghavan<sup>1</sup>, Ralph Morris<sup>1</sup>, Eladio Knipping<sup>2</sup>

This paper presents a comparison of critical loads for acidity of surface waters in the United States with estimates of acidifying nitrogen and sulfur deposition from atmospheric modeling and measurements. Models and measurements offer important complementary features for critical loads studies. Measurements of deposition provide data on atmospheric loading to ecosystems and atmospheric modeling helps fill in gaps in the spatial coverage and chemical composition of the measurements. In this study, critical loads for acidity were obtained from the CLAD US Critical Loads FOCUS database at over 9500 lakes and streams in the US and were examined in conjunction with measured and modeled atmospheric deposition in the US. Wet deposition measurements of sulfate and nitrate at NADP-NTN stations and dry deposition estimates of sulfur dioxide, total sulfate, nitric acid and particulate nitrate at CASTNET monitoring stations were analyzed in addition to deposition simulated by the Community Multiscale Air Quality (CMAQ) model that simulates the emission, transport, chemical transformations and wet and dry deposition of several nitrogen and sulfur compounds. The relative importance of different chemical species in wet and dry deposition as well as uncertainties and limitations in model estimates and measurements are discussed.

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## Critical Loads Approach to Ecosystem Services

T.J. Sullivan and T.C. McDonnell

Public policy decision-making on natural resource issues increasingly relies on two tools: ecosystem services (ES) and critical loads (CL). An integrated approach is applied here to the application of ES and CL for public land management, using as an example the acidification of soil and drainage water by atmospheric deposition of acidifying sulfur (S) and nitrogen (N) compounds. This case study of the central Appalachian Mountain region focuses on areas where effects of acidic deposition on aquatic and terrestrial resources have been relatively well-studied and pronounced. A conceptual framework is presented that illustrates how the ES and CL approaches can be combined in a way that enhances the strengths of each. A suite of ES can be lost or compromised by acidic deposition. Impacted services are associated with maintenance of a healthy fishery resource and the occurrence of benthic macroinvertebrates on which they feed. To a lesser extent, affected ES in this region include adverse impacts on the growth, vigor, and regeneration of sugar maple, which is broadly distributed throughout the study region and which is known to be sensitive to acidification and base cation depletion. Red spruce is also highly sensitive, but only occurs within the study region at scattered high-elevation locations. Impacted aquatic and terrestrial resources are mapped and quantified. They relate to maintenance of healthy trout fisheries and sugar maple trees, including recreational fishing, tourism, aesthetic values, iconic species values, and the cottage industries focused on maple syrup and related sugar maple products.

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## Refining empirical critical loads for nutrient nitrogen: Northeastern pilot study

O'Dea, C.B. and Pardo, L.H.

The most serious threats to forest ecosystems in the U.S. include climate change, pest disturbance and nitrogen (N) deposition. Previous forest ecosystem research has typically focused on the impacts of individual stresses. In order to effectively assess the susceptibility of forests, it is necessary to evaluate the interaction of the effects of these three stressors. One approach for assessing the risk to forest ecosystems from air pollution is the critical load (CL). The CL is the level of deposition below which no harmful ecological effect occurs. The objective of this project was to refine the current estimates of empirical CL for N at the ecoregion scale for the U.S. to a finer spatial scale and by incorporating interactions with climate change and pest disturbance.

In order to refine CL estimates to a 4 km<sup>2</sup> grid scale within our Northeastern pilot study area, we identified abiotic modifying factors and biotic characteristics which can affect CLs. Abiotic modifying factors include elevation, precipitation, and topographic and edaphic factors. For biotic characteristics, we focused on species and habitats of concern to local resource managers. Different species and receptors can have different empirical critical loads. We evaluated available land cover data to best estimate species composition on the ground. We developed a protocol to refine the CL for each grid cell based on abiotic modifying factors and biotic characteristics, and assessed the costs and benefits of making these refinements at different resolutions.

These refinements in CL will make them more accurate and useful to policymakers and resource managers who use critical loads as a scientific basis to assess the impact of N deposition on forests including evaluating the potential impact of new pollutant sources on forest ecosystems. These CL refinements will be incorporated into the CLAD FOCUS database and will be reported to the UNECE in future submissions. In addition, these refinements will be incorporated into a US Forest Service repository to be used for forest management.

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## Critical thresholds of atmospheric deposition in view of changing climatic conditions

Salim Belyazid

The assumption of steady state, i.e. that today's environmental parameters such as climate and land use will remain indefinitely stable, is central to the definition of critical loads of atmospheric deposition. Because this assumption is incorrect, it is imperative to be able to assess the implications of continuously changing environmental factors on the sensitivity of ecosystems to atmospheric pollutants. In recent years, a range of efforts have been directed at identifying these impacts, from laboratory experiments, to ecosystem monitoring, manipulations and dynamic modeling exercises. This talk compiles the results of long-term ecosystem monitoring, field experiments and dynamic modeling studies investigating the effects of climate change (temperature, precipitation, CO<sub>2</sub>) on terrestrial ecosystems. Evidence shows that while environmental changes will most certainly influence the response of ecosystem to air pollution, it is unclear how the critical thresholds will be affected. The concept of target loads may therefore be more robust in informing policy in the future.

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**TECHNICAL SESSION 3:  
URBAN ATMOSPHERIC DEPOSITION**

*Session Chair: Rich Pouyat  
USDA Forest Service*

## MercNet: A National Mercury Monitoring Network

David Evers, BioDiversity Research Institute

## CMAQ estimates of deposition to urban area in the US: Current approaches and future challenges

Donna Schwede<sup>1</sup>, Kathleen Weathers<sup>2</sup>, Jonathan Pleim<sup>1</sup>

Estimating atmospheric deposition to urban areas is an emerging area of interest. Regional air quality models are frequently used to characterize air concentrations near cities and much effort has been made to improve these estimates. Less attention has been given to approaches for modeling total (wet and dry) atmospheric deposition to urban ecosystems, particularly dry deposition. The complexities of the urban landscape present particular challenges in modeling meteorology, chemical transport and, ultimately, deposition. In this study, we show patterns of urban deposition across the US using the Community Multiscale Air Quality model (CMAQ) and contrast the results for different urban areas in the US including New York City, Atlanta, Houston, Chicago, Phoenix, and Los Angeles. These cities each present different challenges in emissions, meteorological, and air quality modeling. We examine the annual deposition of oxidized nitrogen (N) to illustrate differences in chemical species contribution to N deposition and to investigate effects of underlying land use type on model results. Finally, we suggest some next steps for urban deposition research.

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## Pattern and Process in Atmospheric Deposition in Heterogeneous Urban Environments

Tom H. Whitlow

There have been two parallel approaches to studying atmospheric particulate matter (PM) within the discipline of environmental science. The regulatory approach asks the question, "How much is in the air?" while the biogeochemical approach asks, "How much deposits on terrestrial surfaces?" Both approaches emphasize long term, regional trends and patterns, with the result that we know relatively little about patterns and processes occurring in cities and especially near roads and highways which define the urban matrix. Cities have long been recognized as hotspots for producing and processing PM and importantly, where an increasing majority of our population lives. We present a series of case studies using brief monitoring campaigns to illustrate the importance of local, short-term events in determining the loading rates of atmospheric pollutants and the role these play in biogeochemistry and human health and wellbeing. There is an emerging opportunity for synergy between regulatory and basic research monitoring efforts that will allow us to address complex questions of the interacting dynamics of human and ecological systems.

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## Assessing urban influences on ecosystems and the atmospheric

Lucy Hutyra<sup>1</sup>\* and Steve Raciti<sup>1</sup>

Urban areas represent a critical gap in current measurement networks and modeling frameworks that must be addressed to improve understanding of human impacts on the global environment. Nearly three-quarters of anthropogenic greenhouse gas (GHG) emissions are attributable to cities, but most efforts to study atmospheric and terrestrial carbon and nitrogen dynamics avoid urbanized areas. Using an urban-to-rural gradient approach in the greater Boston, MA area as a case study, we have been monitoring greenhouse gas mixing ratios, changes in ecosystem structure and chemistry, and land cover change to systematically evaluate how urbanization impacts on atmospheric chemistry and ecosystem productivity changes. We have found that aboveground biomass (live trees, dbh > 5 cm) for the Boston Metropolitan Statistical Area was  $7.2 \pm 0.4$  kg C/m<sup>2</sup>, reflecting a high proportion of forest cover. Vegetation C was highest in forest ( $11.6 \pm 0.5$  kg C/m<sup>2</sup>), followed by residential ( $4.6 \pm 0.5$  kg C/m<sup>2</sup>), and then other urban developed ( $2.0 \pm 0.4$  kg C/m<sup>2</sup>) land uses. Soil C (0–10 cm depth) followed the same pattern of decreasing C concentration from forest, to residential, to other urban developed land uses ( $4.1 \pm 0.1$ ,  $4.0 \pm 0.2$ , and  $3.3 \pm 0.2$  kg C/m<sup>2</sup>, respectively). Soil N concentrations were higher in urban areas than nonurban areas of the same land use type, except for residential areas, which had similarly high soil N concentrations. Unlike previous studies, we found no significant relationship between NDVI or ISA fraction and foliar %N. Variations in foliar %N appeared to be driven more strongly by changes in species composition rather than phenotypic plasticity across the urbanization gradient. Median atmospheric concentrations of CO<sub>2</sub> within Boston's urban core were  $12.7 \pm 1.4$  ppm greater than concurrent measurements at the rural Harvard Forest study area (~100 km away). Weekday concentrations were 2.1 ppm greater than weekend concentrations, with an 11.1 ppm and 5.1 ppm amplitude in the diurnal cycle on weekdays and weekends, respectively. Taken as a whole, it is still unclear how urban modifications to the growing environment, such as enhanced nitrogen deposition, the urban heat island lengthening the growing season, residential fertilizer applications, and enhanced urban CO<sub>2</sub> concentrations balance against the negative impacts of urbanization such as soil compaction, enhanced ozone and SO<sub>x</sub> concentrations, fragmentation, and human removal of nutrients and organic matter.

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## Effects of urbanization and tree species composition on nitrogen deposition and leaching

Pamela Templer

Forests of the northeastern United States receive elevated rates of atmospheric nitrogen deposition. However, most measurements of nitrogen deposition come from relatively undisturbed, rural locations. In this study, we examined rates of nitrogen deposition and leaching in urban forest stands in Boston, MA and surrounding rural areas to determine fluxes along an urban to rural gradient. Our measurements show that rates of nitrogen deposition are ten times greater within the city of Boston compared to surrounding areas and that some of this can be explained by long-distance transport of pollutants, as well as local sources. Results from this study suggest that additional measurements of atmospheric pollutants should be made within and adjacent to urban areas to better understand and constrain regional estimates of deposition.

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## Atmospheric nitrogen deposition in arid Phoenix, Arizona is lower than expected: Findings from a methods comparison

Elizabeth M. Cook<sup>1</sup>, Sharon J. Hall<sup>1</sup>, Ryan Sponseller<sup>2</sup>, David P. Huber<sup>1,3</sup>,  
Stevan R. Earl<sup>1</sup>, Nancy B. Grimm<sup>1</sup>

Cities occupy a small land area globally, yet atmospheric compounds generated from human-dominated ecosystems have significant impacts on protected lands. Atmospheric nitrogen (N) deposition alters ecosystems, including biogeochemical cycling, primary production, and community composition. In arid ecosystems, considerable uncertainty surrounds estimates of atmospheric N inputs due to variable precipitation and difficulties in quantifying dry deposition. We compared multiple approaches to quantify spatial and temporal patterns of N deposition at locations within Phoenix, Arizona and the surrounding native desert. Using with the Community Multi-scale Air Quality (CMAQ) model for Phoenix (for year 1996; Fenn et al. 2003) as a base for our predictions, we compared N deposition using wet-dry buckets (2000–2005; Lohse et al 2008), ion-exchange resin (IER) collectors (bulk and throughfall, 2006–2012), and inferential methods using passive samplers (atmospheric N concentrations  $\times$  deposition velocity; 2010–2012). We found that rates of N deposition estimated with resin collectors, passive samplers, and wet-dry buckets (median 0.9 mgN m<sup>-2</sup> d<sup>-1</sup>, 0.1–4.1 mgN m<sup>-2</sup> d<sup>-1</sup>) are significantly lower than expected based on CMAQ model estimates (1.1–3.2 mgN m<sup>-2</sup> d<sup>-1</sup>). Contrary to CMAQ model predictions with high deposition within and east of Phoenix, inferential methods show elevated N deposition—in the form of ammonia, nitrogen oxides, and nitric acid deposition—is restricted to the urban core. In addition, we found that patterns of N deposition vary temporally. For example, N throughfall estimates are better predicted by summer monsoon precipitation than winter precipitation. Over two summer and winter seasons, we co-located samplers and directly compared methods for quantifying N deposition at two sites. We found estimates from inferential methods are consistently higher than throughfall estimates in an urban site, whereas inferential methods are lower than throughfall estimates in a non-urban site. Inconsistencies between approaches reveal how uncertainties related to quantifying site characteristics and deposition velocities can easily confound N deposition estimates. Our findings highlight the need for and benefit of mixed methods to quantify wet and dry N deposition in arid systems. Overall, we found that, despite the size and population of arid Phoenix, N deposition is lower than expected compared to other cities and is restricted mainly to the urban core.

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**TECHNICAL SESSION 4:**  
**AGRICULTURE/AMMONIA**

*Session Chair: Wayne Robarge,  
North Carolina State University*

## An improved high-spatial resolution inventory for ammonia emissions from agricultural fertilization

Srinidhi Balasubramanian<sup>1,\*</sup>, Sotiria Koloutsou-Vakakis<sup>1</sup>, Christopher M.B. Lehmann<sup>2</sup>,  
Mark J. Rood<sup>1</sup>

It has been established that improved estimates of ammonia (NH<sub>3</sub>) emissions and long-term field measurements is required to successfully model and evaluate its role in atmospheric secondary aerosol formation and better estimate nitrogen inputs to aqueous and terrestrial ecosystems. Long-term records for wet deposited ammonium (NH<sub>4</sub><sup>+</sup>) are available in the United States but a national network to monitor long term NH<sub>3</sub> concentration trends was implemented only as recently as 2007. Yet, the connection between emissions from various sources and ambient concentrations remains largely uncertain. The need for improved emission estimates from intensive agricultural fertilization (IAF) is recognized as one of the major limitations of current modeling efforts due to coarse spatial resolution (county-level), use of NH<sub>3</sub> emission factors applicable to farming practices in other countries and non-specificity to crop characteristics.

We have developed a new method for a high-spatial resolution NH<sub>3</sub> emission inventory for IAF for the State of Illinois. While current spatial surrogates for IAF do not discern between different intensively managed crop types, our method overcomes this limitation by identifying localized clusters of crop specific emissions. Corn fertilization was identified as the major contributor (~48%) of net NH<sub>3</sub> emissions from IAF followed by Winter Wheat (~15%). Hotspot analysis on the higher spatial resolution inventory indicated localized emissions occurring in central and eastern Illinois. Preliminary spatial autocorrelation studies provided no conclusive evidence for directly relating long term ambient gaseous NH<sub>3</sub> and wet deposited NH<sub>4</sub><sup>+</sup> measurements with improved emission estimates. This points to the need to further closely investigate both the adequacy of the monitoring network and of the emission inventory. In order to understand what improvements in monitoring and emission inventories are needed, we are currently in the process of refining the high-spatial resolution NH<sub>3</sub> emission inventory for IAF to use as a direct input to air quality models and evaluate the impacts at different spatial scales on understanding the fate and transport of NH<sub>3</sub>.

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<sup>2</sup>Illinois State Water Survey

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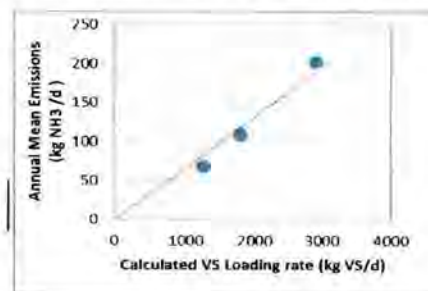
Email address: [sb1sbrm2@illinois.edu](mailto:sb1sbrm2@illinois.edu)

## Ammonia emissions from hog farrow-to-wean waste lagoons

Grant, R.H.<sup>1</sup>, M.T. Boehm<sup>1</sup>, A.J. Lawrence<sup>2</sup>, A.J. Heber<sup>3</sup>, B.W. Bogan<sup>3</sup> and J.C.  
Ramírez-Dorrónsoro<sup>4</sup>

Ammonia (NH<sub>3</sub>) is often viewed as a major contributor to odor from livestock farms, and is a reported gas under the Emergency Planning and Community Right-to-Know Act (EPCRA). NH<sub>3</sub> emissions were measured periodically over the course of two years at waste lagoons of farrow-to-wean farms in Indiana, North Carolina and Oklahoma as part of the National Air Emissions Monitoring Study (NAEMS). One objective of the study was to determine the variation in NH<sub>3</sub> emissions with time of year, atmospheric conditions, and facility operation. Sow populations varied from 1,400 to 2,800 at the three farms. At each measurement site, path-integrated ammonia concentrations were measured along 12 optical paths near the ground around each lagoon using two scanning tunable diode lasers (each laser measuring two adjacent sides of the lagoon). Air pressure, temperature, humidity, and turbulence, and lagoon temperature, pH, and oxidation-reduction potential were also measured. Lagoon volatile solids (VS) loading was calculated based on pig population and average weight. Emissions were calculated from these concentration and turbulence statistics measurements using a backward Lagrangian stochastic model (Windtrax). Analysis showed that daily emissions could be estimated to within 25% if valid measurements were obtained from at least 52% of the day. Applying this threshold resulted in totals of 76 (IN), 34 (NC), and 83 (OK) days available to determine the annual mean daily emissions. The annual mean NH<sub>3</sub> emissions varied from 27 to 52 g NH<sub>3</sub>/d-sow (50 to 118 g NH<sub>3</sub>/d-AU). Annual mean emissions were correlated with the calculated VS loading rates of the lagoons. The annual trend in daily NH<sub>3</sub> emissions showed the expected maximum mean monthly emissions in summer and minimum mean monthly emissions in winter. The annual variation in NH<sub>3</sub> emissions was apparently largely driven by the temperature influence on solubility of dilute NH<sub>3</sub> in water (although the temperature influence on urease activity

may also contribute to the relationship). The correlation between the VS loading and the lagoon emissions had an R<sup>2</sup> of 0.96 (Figure to left). Generally, the operational activities and measured changes in lagoon chemistry did not correlate with the emissions, indicating the relative influence of these variables was less than the error of the measurement.



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## Utilizing the nitrogen isotopic composition of ammonia to investigate regional transport of ammonia emissions: $\delta^{15}\text{N-NH}_3$ values at AMoN sites

J. David Felix<sup>1</sup>, Emily M. Elliott<sup>2</sup>, David Gay<sup>3</sup>

Ammonia ( $\text{NH}_3$ ) emissions are largely unregulated in the U.S. although wet and dry atmospheric deposition of  $\text{NH}_3$  and ammonium ( $\text{NH}_4^+$ ) can be a substantial source of nitrogen pollution to sensitive terrestrial, aquatic, and marine ecosystems. Despite the adverse effects of excess  $\text{NH}_3$  and  $\text{NH}_4^+$  deposition (e.g. eutrophication of surface waters, decreased biodiversity, and increased soil acidity), until recently, gaseous  $\text{NH}_3$  concentrations were not routinely measured as part of the suite of NADP networks. The Ammonia Monitoring Network (AMoN), established in 2007, has rapidly grown to 55 sites. Here, to supplement studies that trace  $\text{NH}_3$  across local landscapes (e.g. conventionally managed cornfields, confined animal feeding operations, dairy operations), we deployed  $\text{NH}_3$  passive samplers at 9 AMoN sites to assess the isotopic composition of  $\text{NH}_3$  ( $\delta^{15}\text{N-NH}_3$ ) as a regional tracer of  $\text{NH}_3$  emission sources. Monthly  $\text{NH}_3$  samples from 9 sites were analyzed for nitrogen isotopic composition over a period of a year (7/09 to 6/10). Our results suggest that isotopic compositions of  $\text{NH}_3$  at individual AMoN sites generally corresponds with primary regional  $\text{NH}_3$  sources. To further explore these spatial patterns, we couple an inventory of the  $\delta^{15}\text{N-NH}_3$  values of  $\text{NH}_3$  sources with county-level  $\text{NH}_3$  emission inventory (Davidson et al. 2002) to model the average monthly  $\delta^{15}\text{N-NH}_3$  values occurring in U.S. counties. These modeled isotopic compositions are then compared to observed  $\delta^{15}\text{N-NH}_3$  values occurring at individual AMoN sites. This comparison provided insight into possible inaccuracies in the  $\text{NH}_3$  inventory and the lack of the modeled isotopic compositions to account for transport of  $\text{NH}_3$  sources. These results demonstrate how the nitrogen isotopic composition of  $\text{NH}_3$  can be utilized to investigate the source, transport, and fate of  $\text{NH}_3$  emissions across varying spatial scales.

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**TECHNICAL SESSION 5:  
BETTER MEASUREMENTS AND TECHNIQUES**

*Session Chair: Dirk Felton*

## Development of the Next Generation of Flux Measurement Tools

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The United States Environmental Protection Agency (EPA) has proposed a pilot program that will add the ability to measure atmospheric fluxes of NO<sub>2</sub> and NO to its existing atmospheric deposition program. Since these fluxes have the potential to impact changes to the secondary National Ambient Air Quality Standards (NAAQS), there is concern about the lack of actual dry flux measurements in current flux assessment schemes. Our research effort will address this concern by creating and deploying a robust, inexpensive, and continuous multiple-species gas-flux monitoring system, which can provide data for a variety of relevant atmospheric pollutants. An inexpensive tool will allow for an exploration of the spatial variability of fluxes as multiple flux measurements would be possible for the same resources as was previously required for a single flux measurement site.

We have designed and built a prototype dynamic flux chamber, which currently measures CO<sub>2</sub> and CO fluxes as well as soil moisture and rainfall. The next step will be to integrate SO<sub>2</sub>, NO, NO<sub>2</sub> and NH<sub>3</sub> gas sensors, as well as meteorological sensors (wind speed, solar radiation, etc.). We are also developing a model that will enable us to compare observed data to existing theory. The complete first-generation chambers cost less than \$2500, and the ultimate goal is to reduce the cost to \$1000 per chamber. This low-cost design is possible because of the use of inexpensive sensors. The sensors range from \$5 to \$150 in cost, and are currently used for alarm indicators in chemical and manufacturing processes. Through previous research efforts, we have demonstrated that these inexpensive sensors are often well suited for environmental assessment applications. The CO<sub>2</sub> sensor that is installed in the chamber is a non-dispersive infrared sensor, with noise of ~1 ppm. Electrochemical sensors will be installed to detect NH<sub>3</sub>, NO<sub>x</sub> and SO<sub>2</sub>. Once these sensors are installed, we will conduct a feasibility study to characterize their performance as well as develop in-field automated calibration tools.

We will present the flux chamber development efforts and show pilot field study results for CO<sub>2</sub>, ozone and possible other pollutants species depending on progress to date. We will also discuss how chamber parameters (volume, flow rate, sensor resolution etc.) affect results. In addition, we will bring the flux chamber to demonstrate the operation of the system.

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## Using measurements and model simulations to understand the cause of the seasonal variation in the oxygen isotopic composition of precipitation along the western US coast

Nikolaus H Buenning<sup>1</sup>, Lowell Stott<sup>1</sup>, Kei Yoshimura<sup>2</sup>, Max Berkelhammer<sup>3,4</sup>

This study seeks to find the primary influence on the seasonal cycle in the oxygen isotopic composition of precipitation ( $\delta^{18}\text{O}_p$ ) along the west coast of the U.S. Archived precipitation samples were gathered from nine stations from the NADP's National Trends Network. The water samples were isotopically analyzed for  $^{18}\text{O}/^{16}\text{O}$  and D/H composition using a Picarro ring down spectrometer. The weekly measurements of  $\delta^{18}\text{O}_p$  were used to calculate long-term monthly means for each station. These data are combined with results from previous studies [IAEA/WMO, 2006; Vachon et al., 2010; Berkelhammer et al., 2012], and mean seasonal  $\delta^{18}\text{O}_p$  cycles are presented for 16 stations along the western U.S. coast. The results document high  $\delta^{18}\text{O}_p$  values in the summer and a drop in  $\delta^{18}\text{O}_p$  during the winter season. The Isotope-incorporated Global Spectral Model (IsoGSM), nudged to reanalysis wind fields, also simulates this wintertime drop in  $\delta^{18}\text{O}_p$  along the west coast of the U.S. However, it is not clear from the standard simulation alone what atmospheric variable(s) are responsible for the seasonal cycle in  $\delta^{18}\text{O}_p$ , and deciphering what controls this isotopic cycle has important implications for paleoclimate studies that seek to use isotope tracers to reconstruct past climate variability. We have investigated what factors give rise to the seasonal drop in  $\delta^{18}\text{O}_p$  in the model by performing a suite of IsoGSM simulations in which individual oxygen isotope fractionation processes were turned off. These simulations reveal that the primary control on the seasonal variations is equilibrium oxygen isotopic fractionation that occurs during vapor condensation. There is almost no influence of the temperature dependence of equilibrium fractionation on the seasonal  $\delta^{18}\text{O}$  cycle for both ocean evaporation and vapor condensation. Additional experiments (including water tagging simulations) were performed to better understand why Rayleigh distillation causes the seasonal variation in  $\delta^{18}\text{O}_p$ . The tagging simulations reveal that vertical oxygen isotope gradients and variations in condensation height are primarily responsible for the seasonal cycle in  $\delta^{18}\text{O}_p$ . The seasonal change in condensation height results from changes in the polar jet and subsequent changes in divergence and vertical velocities, which affects the uplift of moisture. These findings suggest that  $\delta^{18}\text{O}_p$  in the western U.S. is a tracer of condensation height on seasonal timescales. The strong influence of condensation height on  $\delta^{18}\text{O}_p$  complicates efforts to use climate proxy records (such as the  $\delta^{18}\text{O}$  value of tree cellulose) that do not resolve the seasonal cycle since seasonality is likely not static.

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**TECHNICAL SESSION 6:  
NITROGEN DEPOSITION**

*Session Chair: Bill Thompson,  
Penobscot Indian Nation*

## Chemical Transport Modeling of Nitrogen Deposition in the Western U.S.: A National Park Perspective

Michael Barna, Marco Rodriguez, Kristi Gebhart, Bret Schichtel,  
William Malm,

Millions of visitors from around the world enjoy western national parks each year, and often regard these places as a natural refuge from more polluted environs. However, monitoring and modeling studies show that even remote parks are being influenced by air pollution. One example of this trend is nitrogen deposition, which can foster ecosystem change once a critical threshold is reached. Recent wet- and dry-deposition estimates for total nitrogen (defined as nitrogen contributed from nitric acid, ammonium and nitrate) in the western U.S. range between  $0.8 \text{ kg ha}^{-1} \text{ yr}^{-1}$  in western Washington to  $4.2 \text{ kg ha}^{-1} \text{ yr}^{-1}$  in California's Central Valley. At Rocky Mountain National Park, located in northern Colorado and the site of extensive research on the effects of nitrogen deposition to sensitive alpine ecosystems, the measured total wet deposited nitrogen between 2005 and 2009 ranged between  $1.9 \text{ kg ha}^{-1} \text{ yr}^{-1}$  to  $2.5 \text{ kg ha}^{-1} \text{ yr}^{-1}$ , which is greater than the projected 'critical load' of  $1.5 \text{ kg ha}^{-1} \text{ yr}^{-1}$ . It is notable that current monitoring efforts do not consider reduced gaseous nitrogen (namely ammonia), even though significant ammonia sources exist throughout the western U.S. that could potentially have large impacts at downwind national parks. These sources are primarily composed of agricultural operations such as fertilizer application and animal feedlots, and include California's Central Valley, Idaho's Snake River Valley, and northeastern Colorado, and all are examples of ammonia sources near national parks that contain sensitive high-alpine ecosystems. This presentation will discuss results from recent CAMx air quality model simulations for nitrogen deposition at western national parks, with the aim of identifying "hotspots" in sensitive regions that are not currently monitored, and to examine the emission sources that are affecting these areas. In particular, attention will be given to nitrogen species that are not currently monitored, including ammonia, nitrogen oxides, and organic nitrates.

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## Nutrient Criteria Development for Sierra Nevada Lakes

Andrea M. Heard, Dr. James O. Sickman

Atmospheric nitrogen (N) deposition is altering biogeochemical cycles and ecological processes in high-elevation aquatic ecosystems. A need for stricter standards based on measurable ecological effects has been identified as an important step towards their long-term protection. The purpose of our study is to develop nutrient criteria for high-elevation lakes in the Sierra Nevada and apply these criteria to synoptic surveys. The comparison to existing surveys yields information on the temporal and spatial extent of potentially nutrient-affected lakes in the Sierra Nevada spanning the past 20 years and allows us to assess regional effects of atmospheric N deposition.

We are developing nutrient criteria using a bioassay approach where we measured phytoplankton response to N additions. Experiments were conducted *in situ* at four lakes in the Sierra Nevada. Sixteen mesocosms were installed at each site and spiked to create a nitrogen gradient. Phytoplankton response to nutrient additions was measured as chlorophyll *a* and criteria estimated using dose response curves. The dose response curve approach has been successful in developing nutrient criteria for macroalgae in Florida springs and is an attractive approach as it can be used to quantitatively determine effective doses (e.g., 10, 50, 90% doses). The 10, 50, and 90% doses for nitrate in our initial experiments conducted in the early growing season (July) are 0.44, 1.1 (0.7 SD), and 2.6  $\mu\text{M}$ , respectively. The 10, 50, and 90% doses for the late growing season (September) are 0.89, 4.0 (7.5 SD), and 18  $\mu\text{M}$ , respectively. In order to ensure we captured the full range of effective doses, the initial experiments had a wide nutrient gradient (0.0 – 50.0  $\mu\text{M}$ ). Our data show that the nutrient gradient went well above the 10 and 50% thresholds. The experiments were successful in narrowing down the range and estimating initial criteria. However, in order to address the large uncertainties associated with the estimates, we conducted additional experiments to refine the criteria and expanded our spatial sample size to 4 sites in order to investigate variability among lakes. Preliminary results show a measurable response at all four sites with some sites responding at concentrations lower than 1.0  $\mu\text{M}$ . We are modeling these results to refine our criteria estimates and will be presenting these refined estimates along with application of the nutrient criteria to regional surveys, and an assessment of the dose response curve approach to estimating nutrient criteria for Sierra Nevada lakes.

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## Initial Findings from GrandTReNDS: the Grand Teton Reactive Nitrogen Deposition Study

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Despite its sensitive alpine ecosystems and proximity to large agricultural and oil and gas operations, relatively little is known about air quality or nitrogen deposition in Grand Teton National Park (GTNP). The park is located east of large agricultural operations in Idaho's Snake River Valley and northwest of growing oil and gas operations in western Wyoming. Although the park is popular with visitors, it has not historically been home to air quality or deposition monitoring stations. The Grand Teton Reactive Nitrogen Deposition Study (GrandTReNDS) was conducted to provide a first look at air concentrations and deposition fluxes of various reactive nitrogen species. The study took place from April to September 2011. At the study's peak, twelve monitoring stations were in operation in GTNP and the surrounding region. A core measurement site was located on the west side of the park at the Grand Targhee ski resort. Other key measurement stations were located further west near Driggs, Idaho and on the east side of the park at the NOAA Climate Monitoring Station. Study measurements ranged from measurement of gaseous ammonia with Radiello passive samplers to daily URG denuder/filter-pack measurements of PM<sub>2.5</sub> composition and gaseous ammonia and nitric acid concentrations to continuous measurements of key trace gas (NO<sub>x</sub>, NO<sub>3</sub>, NH<sub>3</sub>) concentrations and PM<sub>3</sub> composition measurements with an aerosol mass spectrometer. This presentation will provide an overview of the study and a summary of initial findings. Topics to be discussed include spatial and temporal gradients in key gas and particle phase species concentrations, an overview of the reactive nitrogen deposition budget (including the importance of gaseous ammonia and wet organic nitrogen deposition) on the west and east sides of the park, and an analysis of the contributions of a wildfire that occurred during the study to concentrations of key reactive nitrogen species.

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## Application of USEPA's Watershed Deposition Tool to Estimate Atmospheric Deposition of Nitrogen to the Indian River Basin, Florida

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The Indian River Lagoon (IRL) is a long, narrow, and shallow estuary that extends for 156 miles along the central east coast of Florida and is classified by the USEPA as an Estuary of National Significance for its biological diversity and habitat for endangered species. The north and central sections of the IRL are under the jurisdiction of the St. John's River Water Management District (SJRWMD) and fall within the Group 5 Basins for Total Maximum Daily Load (TMDL) development by the Florida Department of Environmental Protection (FDEP). The Group 5 TMDLs for the IRL include the Banana River Lagoon (BRL) and North and Central IRL. Segments of BRL and IRL are classified by the FDEP as impaired due to loss of seagrass, which is attributed to elevated nutrient loads. We applied USEPA's Watershed Deposition Tool with the Community Multi-Scale Air Quality (CMAQ) Model v4.7 output of reactive nitrogen (N) deposition for 2002 to 2008 to estimate the contribution of atmospherically-deposited nitrogen to total nitrogen loading within the portion of the IRL under the jurisdiction of the SJWMD. For this portion, the CMAQ-simulated 7-yr average deposition rate was 6.68 ( $\pm$  0.10) kg N ha<sup>-1</sup>. Dry and wet deposition contributed approximately 60% and 40%, respectively; and oxidized N and reduced N contributed 80% and 20%, respectively, of the average deposition rate. FDEP's TMDL Report: Nutrient and Dissolved Oxygen TMDLs for the Indian River Lagoon and Banana River Lagoon, March 2009, estimates that of the annual loading to impaired segments of Group 5 Basins 281 metric tons N yr<sup>-1</sup> are from direct atmospheric deposition, 22.1 metric tons N yr<sup>-1</sup> from point sources, and 1,207 metric tons N yr<sup>-1</sup> from non-point sources discharged from the watershed in surface water or in stormwater runoff. For these same segments CMAQ-modeling yielded a direct atmospheric loading to lagoon waters of 426 metric tons N yr<sup>-1</sup> and atmospheric loading to the drainage basin was 1,300 metric tons N yr<sup>-1</sup>. We compared CMAQ-modeled loading rates with those estimated from NADP's wet deposition and CASTNET's dry deposition monitoring sites FL99 and IRL141, respectively, as both sites are within the IRL watershed. CMAQ-modeled atmospheric deposition rates were in reasonable agreement with NADP observations of wet deposition rates of oxidized N and in fair agreement with NADP observations of reduced N, but were significantly higher than CASTNET-modeled dry deposition rates for nitric acid, nitrate, and ammonium.

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**Using National Trends Network Data to Assess Nitrogen Deposition in a Near-Coastal Environment: Marine Corp Base Camp Lejeune (MCBCL), Jacksonville, NC**

Wayne P. Robarge<sup>1</sup> and Karsten Baumann<sup>2</sup>

Long-term sustainability of our nation's military training bases is of critical importance to national security. Presented here are the results of a now concluded multi-year effort to assess and quantify the degree of atmospheric loading of nitrogen (N) and other nutrients arising from wet and dry deposition to the aquatic and terrestrial ecosystems at MCBCL. One question to be addressed by this research was whether National Trends Network data available from nearby collector NC29 at the Hofmann Forest, Onslow Co., NC was sufficient to allow modeling of historic and current trends in N deposition, in order to support development of conceptual/mechanistic ecological models that will lead to effective management for the long-term sustainability of military training. Four battery-powered approved Mercury Deposition Network (MDN) collectors located across MCBCL were used to determine the weekly composition of rainfall from July 2009 – June 2011. Spatial patterns in weekly rainfall amounts were determined using manual rain gauges and tipping-bucket gauges. Both annual (2010) and seasonal data were comparable for inorganic N deposition between MCBCL and the 9-year average values derived from the NC29 dataset (2003 – 2011). However, significant amounts of organic-N in wet deposition (total N minus inorganic N) were present during all seasons of the year, ranging from ~20% in Summer to ~40% in Winter of total N deposition. Reliance on NTN data alone underestimated total N deposition by ~ 1 kg N ha<sup>-1</sup> yr<sup>-1</sup>. Seasonal differences in NH<sub>4</sub><sup>+</sup>-N were evident between the datasets, perhaps due in part to the use of thymol as a preservative. Seasonal differences in SO<sub>4</sub><sup>2-</sup> deposition were also noted, with substantially more SO<sub>4</sub><sup>2-</sup> being recorded during the Summer of 2010 by NTN NC29 than at MCBCL. No readily apparent gradient in N deposition was detected moving inland across MCBCL, thus the results from the 4 MDN collectors were combined to produce an uncertainty estimate. Average annual (2010) wet deposition of total N was 4.3±/0.7 kg N ha<sup>-1</sup> yr<sup>-1</sup>, and for inorganic N was 3.2±/0.4 kg N ha<sup>-1</sup> yr<sup>-1</sup>. As expected, a definite gradient in wet deposition of Cl<sup>-</sup> and Na<sup>+</sup> existed moving inland. Reliance on NTN NC29 data alone would underestimate Cl<sup>-</sup> and Na<sup>+</sup> inputs, both on an annual basis, and especially across seasons of the year. The overall agreement between measured amounts of the wet deposition of inorganic N by this project to the nearby NTN collector NC29 indicates that the amount of atmospheric loading of inorganic N to MCBCL has been relatively constant for at least the past 10 years.

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**State-Level Oxidized Nitrogen Source Attribution from CMAQ for the Chesapeake Bay TMDL Process to Support Air-Water Trading**

Robin I. Dennis, Sergey Napelenok, Mike Dudek

Atmospheric deposition reductions from national CAA rules on NO<sub>x</sub> such as the Clean Air Interstate Rule (CAIR) are factored into the Chesapeake Bay Total Maximum Daily Load (TMDL) allocations. In their State Implementation Plans (SIPs) States may, however, go beyond national CAA rules to meet CAA air quality standards locally. The tributary nitrogen load reductions allocated to the states to meet the TMDL target for Chesapeake Bay are large and not easy to attain via controls on water point and nonpoint sources. It could be important to the TMDL process to take advantage of air emissions reductions that would occur with SIPs that go beyond the national air rules. The additional air deposition reductions could then be used to offset water quality controls (air-water trading). What is needed is a source to receptor transfer function that connects emissions from a state to deposition to a tributary. We would like to do this without having to run the regional air quality model many times over because it is computationally expensive. There is a special source attribution version of CMAQ (DDM-3D) that can estimate the fraction of deposition contributed by labeled emissions (labeled by source or region) to the total deposition across space. We use the CMAQ DDM-3D version to set up simplified state-level delta emissions-to-delta atmospheric deposition transfer coefficients by major source sectors within a state, since air regulations are generally at the state level. The CMAQ 4.7.1 calculations are performed at a 12 km grid size over the airshed domain covering Chesapeake Bay for 2020 CAIR emissions. For results, we first present the fractional contributions of state NO<sub>x</sub> emissions to the oxidized nitrogen deposition to the Chesapeake Bay watershed and Bay. We then present example tables of the fractional contributions of state NO<sub>x</sub> emissions from mobile, off road, power plant and industrial emissions to key tributaries: the Potomac, Susquehanna and James Rivers. Finally, we go through an example for a mobile source NO<sub>x</sub> reductions in Pennsylvania to show how the tributary load offset would be calculated using the factors generated by CMAQ DDM-3D.

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**Examination of Aquatic Acidification Index (AAI) component variability and implications for characterizing atmospheric and biogeochemical nitrogen processes.**

Richard Scheffe, Adam Reff, Jason Lynch and James Kelly

In 2006, EPA began the development of a secondary air quality standard to protect U.S. aquatic ecosystems from deposition of ambient oxides of sulfur and nitrogen (SO<sub>x</sub>/NO<sub>y</sub>). These efforts culminated in a quantity called the Atmospheric Acidification Index (AAI), which was a regionally representative parameter that was intended to project a water quality level resulting from depositing concentrations of SO<sub>x</sub>/NO<sub>y</sub>. This work presents results of subsequent analyses that 1) explores the possibilities of more flexible and efficient formulations of the AAI, 2) evaluates the plausibility of the AAI approach against ANC measurement data, and 3) investigates variability of AAI component variables to aid in planning future data collection efforts.

Current AAI evaluation results generally show strong correlations (e.g.,  $R^2 > 0.9$ ) between newly developed water-body specific AAI values and ANC measurements at over 900 water bodies across the U.S. Spatial patterns of AAI values capture relative adversity with respect to our current understanding of impacted surface waters across the nation. Future year projections suggest that aquatic acidification gradually will shift from an eastern U.S. focus driven largely by sulfur deposition toward a more evenly distributed picture of aquatic acidification nationally, with significant improvement in eastern systems and increasing importance of nitrogen deposition throughout the country (especially reduced forms) relative to sulfur. Analysis of atmospheric and biogeochemical components of the AAI model indicate greater relative variability associated with heterogeneity of surface and sub-surface features, suggesting that enhances in the frequency and distribution of water quality monitoring be considered together with air monitoring design for future applications.

**TECHNICAL SESSION 7:  
UNDERSTANDING TOTAL DEPOSITION OF  
NITROGEN AND SULFUR**

*Session Chair: Tom Butler,  
Cornell University*

## New York's plan to enhance the pilot monitoring project to inform the next review of the secondary standards for oxides of nitrogen and sulfur

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The US EPA's development of the aquatic acidification index (AAI) to address the secondary national ambient air quality standards for oxides of nitrogen and sulfur was a novel multi-pollutant, multi-media approach to air quality management. Although the Agency chose to retain the current standards until the next round of review, the final rule calls for a pilot monitoring program in 3-5 sensitive ecoregions across the country to evaluate Federal Reference Methods for sulfur and nitrogen oxides, dry deposition measurements and algorithms, and ultimately the usefulness of the AAI to protect public welfare. The Adirondack Mountain region in northern New York, which has been impaired by acid deposition and has a long record of air, deposition and water quality data which were used to help develop the AAI, was selected as one of these sensitive ecoregions. The US EPA plans to augment current wet (NADP/NTN) and dry (CASTNet filter pack, CFP) deposition measurements at Huntington Wildlife with a passive NH<sub>3</sub> sampler and a continuous NO<sub>y</sub> analyzer. The New York State Department of Environmental Conservation (NYSDEC) and partners plan to enhance the pilot monitoring efforts by supporting CFPs and passive NH<sub>3</sub> at two additional wet deposition sites in the Adirondacks. The first site – Moss Lake – is in the southwestern part of the Adirondacks, a region with many lakes and streams still impacted by the effects of acid deposition. The other site – Whiteface Mountain – is in the "High Peaks" region with a wealth of co-pollutant data, including cloud chemistry data, PM<sub>2.5</sub> mass and speciation, and continuous SO<sub>2</sub>. The NYSDEC also plans to transition its own wet deposition samplers to NADP/NTN samplers to provide additional information in and around the Adirondack region. These enhanced monitoring efforts will provide additional spatial information to better evaluate the variability of deposition and the AAI across the region.

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## Transference Ratios to Predict Total Oxidized Sulfur and Nitrogen Deposition

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Use of model-predicted "transference ratios" is currently under consideration by the US EPA in the formulation of a Secondary National Ambient Air Quality Standard for oxidized nitrogen and oxidized sulfur. This term is an empirical parameter defined for oxidized sulfur (TS) as the ratio of the total oxidized sulfur deposition (from dry plus wet deposition) to the airborne concentration of oxidized sulfur. A multi-year record of weekly measured and data-derived quantities at selected monitoring sites in the eastern US was examined to determine the variability of TS that might be expected from field measurements. Weekly TS displayed considerable variability that depended on site, season, and year, but according to ANOVA, most heavily on site and season. Using weekly data, the variability of deposition-related quantities and error propagation analysis of TS both suggest that variation in parameters related to wet deposition processes are generally more important than variation in parameters related to dry deposition processes in determining variation in TS. Correlations between airborne seasonal concentration of oxidized sulfur and the various components of seasonal deposition (i.e., dry, wet, and total) also underscore the strong influence that the variability in wet deposition processes can have on estimates of total deposition. Analysis of monitoring results suggests that 95% CI for TS using weekly results over several years for a specific site and season could be as large as  $\pm 235\%$ , but only as large as  $\pm 33\%$  using annual aggregates for a specific site. At the annual scale, a regression model of the form that incorporates a site-specific transference ratio, yielded estimates of total oxidized sulfur deposition to within  $\pm 25\%$  of the monitored values  $\geq 95\%$  of the time. Since all of the major oxidized nitrogen species are not monitored regularly, a parallel analysis was limited to only the monitored oxidized nitrogen species. Nevertheless, findings for monitored oxidized nitrogen are consistent with those described above for oxidized sulfur. These results suggest that at specific sites in the eastern US, annual estimates of total deposition to within  $\pm 25$  to  $\pm 35\%$  may be expected using species- and site-specific transference ratios along with annual average monitored airborne concentrations.

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## Evaluation and Variability of Chemical Transport Models Sulfur and Nitrogen Compound Deposition and Ambient Concentration Estimates

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Sulfur and nitrogen deposition are critical variables for evaluating the potential for acidification of watersheds. Available deposition measurements have limited spatial coverage, lack high temporal frequency and have incomplete representation of all species. Thus, air quality models are increasingly used to develop estimates of dry and wet deposition of sulfate and nitrate compounds in watersheds in an effort to determine the acidifying deposition loads into the aquatic systems. However, these models need to be rigorously evaluated to ensure that one can rely on the modeled quantities instead of the measured quantities. In the U.S., these models are also being proposed to be used in establishing national standards based on modeled quantities. The U.S. Environmental Protection Agency (EPA) is considering acidification as the main ecological endpoint of concern in determining the secondary national ambient air quality standards for nitrogen oxides and sulfur oxides. Acidification is tied to depositions of sulfur and nitrogen, which are linked to ambient concentrations of the elements. As EPA proposes to use a chemical transport model in linking deposition to ambient concentration, it is important to investigate how the currently used chemical transport models perform in predicting depositions and ambient concentrations of relevant chemical species and quantify the variability in their estimates. In this study, three annual simulations by Community Multiscale Air Quality (CMAQ) modeling system and two annual simulations by Comprehensive Air Quality Model with Extensions (CAMx) for the entire continental U.S. domain are evaluated against available measurement data (including NADP) for depositions and ambient concentrations of sulfur oxides and reactive nitrogen species. The model performance results vary by evaluation time-scale and geographical region. Evaluation of annualized quantities (annual average ambient concentrations and annual total depositions) suppresses the large variances shown in the evaluation using the observation's native shorter-term time-scales (e.g., weekly). In addition, there is a large degree of bias and error (especially for deposition fluxes) in the modeling. The variability in the ratio of deposition to ambient concentration, so-called the transference ratio that EPA has proposed to use in linking deposition to ambient concentration, is also examined and are shown to vary considerably by geographical region and by model simulation.

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## Measurement of air-surface exchange of speciated nitrogen and sulfur compounds using a modified MARGA 2S: Assessment and control of data quality

Ian C. Rumsey\*, John T. Walker

Improved measurement methods are needed to characterize dry deposition of sulfur and nitrogen compounds to assess ecosystem exposure to nutrients and acidifying compounds and to develop atmospheric deposition budgets in support of critical loads assessments. The purpose of this study is to develop an integrated measurement system for speciating the dry deposition budget of nitrogen and sulfur using micrometeorological flux measurement approaches. The Monitor for AeRosols and GAses in ambient air (MARGA) is an on-line analyzer that measures gases and soluble ions in aerosols at an hourly temporal resolution. The MARGA utilizes a Wet Rotating Denuder (WRD) to collect gases, while aerosols are collected by a Steam Jet Aerosol Collector (SJAC). A modified version of the MARGA 2S was used, which employs dual sample collection boxes, to measure vertical gradients of gas phase ( $\text{NH}_3$ ,  $\text{HNO}_3$ ,  $\text{HONO}$ , and  $\text{SO}_2$ ) and particulate ( $\text{NH}_4^+$ ,  $\text{NO}_3^-$ , and  $\text{SO}_4^{2-}$ ) for the purpose of calculating air-surface exchange fluxes via the modified Bowen-ratio technique. The presentation describes the modifications to the standard MARGA 2S employed to facilitate gradient measurements and the primary aspects of data quality assessment and control as related to concentration and gradient measurements. These include the characterization and control of the stability of  $\text{NH}_x$  ( $\text{NH}_3 + \text{NH}_4^+$ ) in liquid solution, control of accuracy in both the analytical and air sampling components of the system as well as co-location experiments to characterize precision. Methods for quantifying concentration and gradient detection limits are also described within the context of quantifying flux detection limits and overall uncertainty in measured fluxes.

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## Measurement of air-surface exchange of speciated nitrogen and sulfur compounds using a modified MARGA 2S: Concentrations and fluxes above a grass field

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Improved measurement methods are needed to characterize dry deposition of sulfur and nitrogen compounds to assess ecosystem exposure to nutrients and acidifying compounds and to develop atmospheric deposition budgets in support of critical loads assessments. The purpose of this study is to develop an integrated measurement system for speciating the dry deposition budget of nitrogen and sulfur using micrometeorological flux measurement approaches. The Monitor for Aerosols and Gases in ambient air (MARGA) is an on-line analyzer that measures gases and soluble ions in aerosols at an hourly temporal resolution. A modified version of the MARGA 2S was used, which employs dual sample collection boxes to measure vertical gradients of gases ( $\text{NH}_3$ ,  $\text{HNO}_3$ ,  $\text{HONO}$ , and  $\text{SO}_2$ ) and aerosols ( $\text{NH}_4^+$ ,  $\text{NO}_3^-$ , and  $\text{SO}_4^{2-}$ ) for the purpose of calculating air-surface exchange fluxes via the modified Bowen-ratio technique. The presentation describes preliminary measurements of gas and aerosol concentrations and fluxes above a grass field, during the late spring and summer of 2012, with a focus on flux data quality. The contribution of micrometeorological and chemical measurements to total uncertainty in the fluxes is examined. The general features of the compound-specific fluxes, including relationships with meteorological and surface characteristics, are also discussed along with the relative importance of individual nitrogen compounds to the total flux of  $\text{NH}_3 + \text{HNO}_3 + \text{HONO} + \text{NH}_4^+ + \text{NO}_3^-$ .

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## Assessment of Long-term Monitoring of Nitrogen, Sulfur, and Mercury Deposition and Environmental Effects in New York State

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Air pollutants such as nitrogen oxides, sulfur dioxide, and mercury have had significant impacts on lakes, rivers, soils, fauna, and tree health throughout the northeastern US. Some areas of New York State are particularly susceptible to environmental degradation, such as the Adirondack and Catskill regions, which receive some of the highest rates of acid and mercury deposition in the country. Long-term monitoring (LTM) efforts in New York State have produced data sets that have been extremely valuable for evaluating changes over time in air pollution loads and effects on the environment. It is important to evaluate LTM programs periodically to ensure that these programs remain efficient and effective. To our knowledge, a comprehensive evaluation of long-term environmental monitoring has never been undertaken in New York State. Such an analysis is necessary to identify possible improvements in sampling designs to maximize information gained relative to the resources required for data collection.

We performed a comprehensive analysis of acid and mercury atmospheric deposition and environmental effects in New York. We used a variety of statistical approaches to assess current sampling schemes in six topic areas: atmospheric deposition, lakes, streams, vegetation, soils, and fauna. Using this information, we were able to assess whether current monitoring efforts are sufficient to identify long-term recovery trends, and also to assess whether some monitoring programs may be able to reduce current sampling efforts and apply these efforts to additional monitoring projects. In general, we found that state-wide coverage of wet deposition monitoring is sufficient for measuring long-term trends in acid deposition, but that records of wet mercury deposition were often not long enough to reflect any significant trends. We found that statewide stream chemistry sampling is sufficient, but that there is little information in the state on small, acid sensitive streams or on stream export. We suggest ways that lake sampling might be redistributed to better identify trends in lake chemistry and biota for the same amount of effort expended. We also used a power analysis to assess the change needed to detect a significant difference in a variety of environmental variables such as loon and fish mercury, lake water and sediment mercury concentrations, soil nutrient concentrations, and stream concentrations based on a variety of one-time surveys. We hope that the methods used in this assessment will be widely applicable to researchers interested in evaluating long-term monitoring programs throughout the country.

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**TECHNICAL SESSION 8:**  
**MERCURY**

*Session Chair: Barry Mower,  
Maine DEP*

## Mercury wet deposition to a remote island in the west Pacific Ocean and a high-elevation site in central Taiwan

Guey-Rong Sheu<sup>\*†</sup>, Neng-Huei Lin<sup>†</sup>

Weekly rainwater samples have been collected at Pengjiayu and Lulin Atmospheric Background Station (LABS) for total Hg analyses since late 2008 and early 2009, respectively. Pengjiayu is a small remote island in the west Pacific Ocean, with an area of 1.14 km<sup>2</sup> and about 56 km distance to the north of Taiwan. Rainwater is sampled at Pengjiayu Weather Station (25°37'46"N, 122°4'16.5"E, 101.7 m a.s.l.). On the contrary, LABS is a high-elevation background site in central Taiwan (23°28'8.4"N, 120°52'12"E, 2862 m a.s.l.). Here we reported the results of Hg wet deposition sampled in 2009 and 2009/04-2010/03 for Pengjiayu and LABS, respectively. A total of 35 rainwater samples were collected at Pengjiayu. Sample Hg concentrations ranged between 2.25 and 22.33 ng L<sup>-1</sup>, with a volume-weighted mean (VWM) concentration of 8.85 ng L<sup>-1</sup>. Seasonal VWM concentrations were 7.23, 11.58, 7.82, and 9.83 ng L<sup>-1</sup> for spring, summer, fall, and winter, respectively. A total of 27 rainwater samples were collected at LABS; however, no samples were collected in 2009/08-09 due to road damage and electricity failure caused by a powerful typhoon. Sample Hg concentrations ranged between 3.17 and 37.84 ng L<sup>-1</sup>, with a VWM concentration of 8.06 ng L<sup>-1</sup>. Seasonal VWM concentrations were 7.64, 9.47, 9.15, and 5.12 ng L<sup>-1</sup> for spring, summer, fall, and winter, respectively. These annual VWM concentrations were comparable to the 2009 values reported by the Mercury Deposition Network (MDN) for the Southeastern and upper Midwestern states in USA. High rainwater Hg concentrations in summer were also observed at some MDN sites. Since there is no major anthropogenic Hg emission source at or near Pengjiayu and LABS, the observed high summertime rainwater Hg concentration hints the importance of Hg<sup>0</sup> oxidation and/or scavenging of upper-altitude Hg(II) by deep convection. Direct anthropogenic Hg(II) emissions from the East Asian continent may not contribute significantly to the measured rainwater Hg concentrations; however, anthropogenic Hg<sup>0</sup> emissions may be transported to the upper troposphere or marine boundary layer where it can be oxidized to produce Hg(II), which will then be effectively scavenged by cloud water and rainwater.

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## RAMIX - A Step towards Understanding Atmospheric Mercury Chemistry and Tekran<sup>®</sup> Observations

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From August 22 to September 16, 2012, atmospheric mercury (Hg) was measured from a common manifold using different methods during the Reno Atmospheric Mercury Intercomparison eXperiment (RAMIX). This was the first experiment to measure atmospheric Hg while spiking elemental Hg, HgBr<sub>2</sub>, ozone, and water vapor into a manifold in the field. During this project, the University of Nevada group operated one Tekran<sup>®</sup> 2537 unit and two Tekran<sup>®</sup> 2537/1130/1135 systems, while the University of Washington team managed the Detector for Oxidized Hg Species (DOHGS), and the group from University of Miami applied a Laser-Induced Fluorescence (LIF) technique and operated a Tekran<sup>®</sup> 2537 unit. The spiking manifold was designed by the University of Washington group and operated independently of those managing the DOHGS during the experiment. Spike recoveries were calculated when data were collected simultaneously by one free standing Tekran<sup>®</sup> system and by one connected to the sampling manifold. Using the Tekran<sup>®</sup> data, GEM recoveries were ~76 ± 7%, while for HgBr<sub>2</sub> these were 17 ± 3%. O<sub>3</sub> and water vapor spike recoveries ranged from 81 to 95% and 88 to 110%, respectively. The low HgBr<sub>2</sub> recovery by the Tekran<sup>®</sup> system could be attributed to loss of the spike in the manifold, low recovery by the denuder, ozone and water vapor interferences, or instrument artifacts.

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**A novel approach: Using financial market technical indicators to assess temporal trends in mercury deposition and concentrations.**

Arnout ter Schure and David Gay

For years, trading decisions related to the financial markets have been based on momentum and stochastic oscillators among other technical indicators (TIs). Two of these TIs are the Moving Average Convergence-Divergence (MACD, a momentum oscillator based on the difference between two Exponential Moving Averages (EMAs)); and the stochastic oscillator (STO, which shows how in the case of financial markets a stock's price is doing relative to past movements). Given that these TIs are easily calculated and are independent of the nature of the underlying data-set, they are a potential powerful (easy to use, cheap and accurate) tool to assess temporal trends and changes in trends within other types of data as well; in this case that of mercury (Hg) wet deposition and mercury concentrations in rainfall as measured by the Mercury Deposition Network (MDN). Here, results of the MACD and STO analyses for MDN sites with at least 10 years worth of data, representing the "four corners" of the continental United States, are represented. Our analyses show that the MACD and STO can reveal long term (years) and short term (seasonal) changes in Hg deposition, differences in changes between sites, as well as provide insights if current trends will continue or not.

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**Investigating sources of gaseous oxidized mercury in dry deposition at three sites across Florida, USA**

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Hg in wet deposition in Florida is high compared to the rest of the United States, however there is little information on Hg dry deposition. From July 2009 to August 2010 passive samplers for the measurement of air Hg concentrations, and surrogate surfaces for measurement of Hg dry deposition, were deployed at locations near Ft. Lauderdale (DVE) and Pensacola (OLF), and in Tampa (TPA). These samplers were co-located with air quality monitoring stations put in place to collect data for development of a statewide total maximum daily load (TMDL) for mercury (Hg). All sampling locations were within 15 km of 1000 MW electricity generating plants (EGPs) and major highways. The overall objectives of this work were to: 1) investigate the utility of the passive sampling systems in an area with low and consistent air concentrations, 2) estimate dry deposition of gaseous oxidized Hg, and 3) investigate potential sources. Using 24 hour, biweekly, and seasonal Hg observations, criteria air pollutants, and meteorological data collected at each site, the potential sources of Hg deposited to surrogate surfaces were investigated. Using these data and event analyses, *in situ* oxidation of Hg appears to be a process contributing to deposition. The greatest deposition was measured at TPA where the sampling location was surrounded by highways. Hg imported into the area associated with long range transport is contributing to deposition measured at all sites in the spring. Local EGPs contribute GEM to the DVE site however the GOM contribution is uncertain. Based on the data collected with the Tekran<sup>®</sup> and passive sampling systems, we suggest that different chemical forms of Hg are associated with these sources.

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**Comparing 6 years of event-based rainfall deposition of mercury, trace metals and major ions collected close to a coal-fired power plant with nearby NADP/MDN sites.**

Arnout ter Schure, Jane M. Caffrey,  
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Event-based (24-hour integrated) rainfall deposition of mercury (Hg), trace metals (Se, As, etc), and major ions ( $\text{SO}_4$ ,  $\text{NO}_3$ ) has been monitored over the last 6 years at 4 locations (3 inland locations and 1 close to the coast over the past 2 years) around coal-fired power plant (CFPP) Crist in Pensacola, FL. Over the years, emissions in the region have changed as a result of an increasing population, along with Hg emission controls at the CFPP, providing a great opportunity to evaluate the temporal and spatial patterns in atmospheric wet deposition. One goal of this project was to quantify the contribution of local emission sources—in this case the CFPP—to the total atmospheric deposition flux of mercury and other metals to the Pensacola Bay Watershed. There were no significant differences in the rainfall Hg flux between the three inland sites or between nearby MDN monitoring sites along the Gulf Coast. Mercury deposition during the summer months is higher than other months due to higher concentrations in the rainfall and higher summertime rainfall rates throughout the region. Sulfate deposition shows a consistent decline at the 3 inland sites over the years. The Hg/ $\text{SO}_4$  and Hg/ $\text{NO}_3$  ratios in wet deposition can be used to assess long term changes in emissions and different types of weather systems that control short term variability. The seasonal pattern in Hg/ $\text{SO}_4$  in precipitation is in the summer and fall in recent years about twice that of the previous seasons. In addition, the Hg/ $\text{SO}_4$  and Hg/ $\text{NO}_3$  ratios are lower compared to that of nearby NADP/MDN sites.

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**Aquatic Mercury Assessment of the Savannah River Site**

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An aquatic mercury assessment of the Savannah River Site (SRS), an 800 km<sup>2</sup> facility along the Savannah River in South Carolina, was performed to evaluate mercury flux to the surrounding ecosystem. The study produced a diverse dataset collected over three years, investigating: 1) mercury concentration and speciation in industrial discharges, streams, and river; and 2) precipitation concentration/atmospheric deposition.

Mercury inputs totaled approximately 17.3 kg/yr and consisted of: influent from an offsite stream (0.1 kg/yr), mercury added by SRS operations via the NPDES outfalls (0.2 kg/yr), and atmospheric deposition (10 kg/yr wet and 7 kg/yr estimated dry). Mercury outputs consisted primarily of effluents via multiple site streams (1.1 kg/yr). Assuming an approximate mass balance, the sum of the mercury storage and re-volatilization within the SRS boundary was approximately 16.2 kg/yr. Thus, greater than 90% of the mercury input is being retained in the soil, sediments, water bodies and vegetation, and/or is being reemitted to the atmosphere. Mercury released through the SRS outfalls was equivalent to approximately 1% of the total atmospheric deposition on the SRS, indicating that atmospheric deposition is the major source of mercury to the SRS environment. These findings are similar to many other studies (Lindberg et al. 2002, Erickson and Gustin 2004, Erickson et al. 2002, Hintelmann et al 2002, Landis and Keeler 2002), which found that, for a variety of settings, a significant fraction of mercury is atmospherically deposited and that these mercury inputs are often bound to soil and vegetation. In general, the baseline mercury characterization documented that SRS is a typical coastal plain site and that mercury entering the site's water sheds and ecosystems is subject to transport and transformation processes that are analogous to other sites in the southeast.

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## Seasonal variation in pathways of atmosphere-land exchange of mercury in a northern hardwood forest

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Northern forest ecosystems can be sensitive to atmospheric mercury deposition. In this study we integrated data collected at the Huntington Wildlife Forest in the Adirondack region of New York to examine seasonal variation in pathways of mercury exchange between the atmosphere and the forest ecosystem. The data included concentrations of atmospheric mercury, wet mercury deposition (Mercury Deposition Network), throughfall mercury, foliar accumulation of mercury, litterfall mercury deposition, soil mercury evasion, soil solution mercury fluxes as well as estimates of mercury deposition predicted from the atmospheric transport model CMAQ. In this analysis we examined mercury transfers at a monthly time step over the annual cycle using average data over recent years (2004-2011). Depletion of gaseous elemental mercury during the growing season generally agreed with foliar mercury accumulation and litter mercury deposition. This pathway was the largest annual influx of mercury as dry mercury deposition ( $14.3 \mu\text{g}/\text{m}^2\text{-yr}$ ) exceeded wet mercury deposition ( $6.7 \mu\text{g}/\text{m}^2\text{-yr}$ ). Soil evasion was the greatest mercury loss pathway ( $6.4 \mu\text{g}/\text{m}^2\text{-yr}$ ), exceeding vertical and lateral drainage from soil ( $2.8 \mu\text{g}/\text{m}^2\text{-yr}$ ). Field measurements of mercury fluxes generally did not agree well with CMAQ simulations of mercury deposition. The upland hardwood forest was a net sink for mercury inputs. Our analysis showed marked seasonal variation in the transfers of mercury largely mediated by annual canopy development of the forest ecosystem.

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## Recent progress on mercury deposition studies

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Mercury (Hg) dry deposition at multiple locations in eastern and central North America were estimated using AMNeT data. The estimated Hg dry deposition agrees well with limited surrogate-surface dry deposition measurements of gaseous oxidized Hg (GOM) and particulate-bound Hg (PBM) and also agrees well with litterfall Hg measurements conducted at multiple locations in this region. Results suggest that gaseous elemental Hg (GEM) contributes much more than GOM+PBM to the total dry deposition at the majority of the sites, the only exception is at locations close to significant point sources where GEM and GOM+PBM contribute equally to the total dry deposition. The relative magnitude of the speciated dry deposition and their good comparisons with litterfall deposition suggest that mercury in litterfall originates primarily from GEM. Total dry deposition of mercury is equal to, if not more important than, wet deposition of mercury on a regional scale in eastern North America.

Daily samples of bulk PBM dry deposition and size-fractionated (18, 10, 2.5 and 1.0  $\mu\text{m}$ ) PBM concentration were collected at three sites in central Taiwan. On annual average,  $\text{PM}_{10}$  contributed more than 50% to the bulk concentration at the traffic and the industrial sites and contributed 25% at the wetland site,  $\text{PM}_{10-2.5}$  contributed 25% to 50%, and coarse fraction ( $\text{PM}_{2.5-10}$ ) contributed 7% to 25%. Samples with very high bulk concentrations had large fine fractions. Coarse PBM was estimated to contribute 50-85% of the total PBM dry deposition. Daily dry deposition velocities ranged from 0.01 to 7.7  $\text{cm s}^{-1}$  with annual averages of 0.29-0.60  $\text{cm s}^{-1}$ . These values can be reasonably reproduced using a size-resolved model and measured size fractions.

The Maximum Likelihood Estimation method was used to establish a statistical relationship between wet deposition amounts measured in MDN and atmospheric concentrations measured in AMNeT. Three super stations were selected to establish the regression model which was further validated using datasets from the other seven monitoring stations in eastern USA. The model is capable of partitioning atmospheric GOM and PBM using wet deposition measurements and thus increasing the spatial coverage of GOM and PBM by taking advantage of the more extensive spatial coverage of the wet deposition network.

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**POSTER SESSION**

IN ALPHABETICAL ORDER BY AUTHOR

## Ammonia field measurements and CMAQ comparisons at some "clean" sites in the northeastern US: Implications for total N deposition

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We have measured low NH<sub>3</sub> concentrations from 2006 to 2011 at a site in upstate NY (NADP/AIRMon- NY67; CASTNET - CTH 110), and during some of this period at two other low NH<sub>3</sub> concentration sites (ARN, 13 km SE of CTH, and KEF in the Allegheny National Forest, 200 km WSW of CTH) and an agricultural site (HFD, 40 km SE of CTH) for comparison. Comparisons of passive NH<sub>3</sub> measurements with CMAQ estimates (2002 to 2008) of concentration and deposition were made. At CTH, NH<sub>3</sub> concentration measurements for 2007 and 2008 compare well overall (slope of Passive vs CMAQ = 1.02) with a mean value of 0.49 µg NH<sub>3</sub>/m<sup>3</sup> for the passive measurements and 0.52 for CMAQ estimates. However there is some scatter in the comparison (r<sup>2</sup> = 0.57) with CMAQ showing higher concentrations in the summer. KEF shows lower annual concentrations than CTH, and CMAQ has lower values (annual mean = 0.10 µg NH<sub>3</sub>/m<sup>3</sup>) than the passive measurement concentrations (annual mean = 0.23 µg NH<sub>3</sub>/m<sup>3</sup>).

Measured NH<sub>3</sub> concentrations at CTH, ARN and KEF all show a similar temporal pattern (high NH<sub>3</sub> in late spring and summer, low in winter), representing a regional background level of NH<sub>3</sub>. However, the agricultural site (HFD) does not follow this pattern, with high concentrations driven by very localized emissions. The potential for high ambient NH<sub>3</sub> concentrations (2 to 7 µg NH<sub>3</sub>/m<sup>3</sup>) exists throughout the year at HFD and are most likely the result of manure and fertilizer application. Transects of NH<sub>3</sub> concentrations across the HFD farm site and beyond show a decline from 6 to 14 µg NH<sub>3</sub>/m<sup>3</sup> to ~2 µg NH<sub>3</sub>/m<sup>3</sup> within about 1 km of the farm center, further indicating the very localized distribution of NH<sub>3</sub> concentration in an agricultural area. CMAQ model results do not show the temporal and spatial concentration changes measured by the passive samplers at the HFD site.

Converting concentration estimates to nitrogen deposition of NH<sub>3</sub> depends on estimates of deposition velocity or bidirectional flux parameters. The differences in these two approaches are presented, and the relative importance of NH<sub>3</sub> deposition to other forms of N deposition is analyzed. In addition, other nitrogen deposition parameters (e.g. NO<sub>2</sub>, NO<sub>3</sub><sub>(p)</sub>, NH<sub>4</sub><sub>(p)</sub>, HNO<sub>3</sub>, wet NO<sub>3</sub><sup>-</sup> and NH<sub>4</sub><sup>+</sup>, etc.) are assessed, and estimates of total deposition are presented. The relative importance of NH<sub>3</sub>, even at low concentration sites, will be demonstrated.

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## Long-term wet deposition, particulate, and gas-phase sulfur and nitrogen measurements in New York State

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The New York State Department of Environmental Conservation (NYSDEC) has monitored air quality and wet deposition in urban, suburban, and rural areas across the state for decades. These long-term measurements are used to help evaluate the impacts of federal, regional, and state pollution control measures. The NYSDEC wet deposition network complements the NADP program in the state by capturing the effects of local sources and roadways, providing deposition data across a wider range of landscapes. Data records from the NYSDEC network are robust enough to infer trends and exhibit substantial declines in acid deposition and criteria pollutant concentrations. Here we present a comparison of deposition and concentration trends in sulfur and nitrogen species between urban and rural locations in New York. Consistent with findings from national monitoring programs such as the NADP, CASTNet, and IMPROVE, air concentrations and wet deposition of sulfur and nitrogen compounds across New York have decreased by about 40% or more over the past 2-3 decades.

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## Bag Sampling with NADP NTN and AIRMoN Wet Deposition Samples

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The National Atmospheric Deposition Program's National Trends Network (NADP/NTN) and Atmospheric Integrated Research Monitoring Network (NADP/AIRMoN) began operations in 1978 and 1992, respectively. Throughout their history, both networks have collected wet-deposition precipitation samples using 3.5 gallon food grade plastic buckets. In 2011, a series of tests was conducted to assess the impact of evaporation on a sample's volume and its chemistry. Results of that testing suggest that despite efforts to clean the food grade buckets after each use, a biological component can persist. This has implications for the nitrogen species (e.g., nitrate and ammonia) present in NTN and AIRMoN samples. The presence of phosphate in the sample was found to increase both the rate and the magnitude of nitrogen loss in the samples.

Several procedural changes were tested in an attempt to eliminate the biological component from the walls of the sample buckets including both hydrogen peroxide and peracetic acid at varying concentrations, different application methods, and different contact times. These methods were found to be ineffective, impractical, or presented safety concerns for laboratory staff.

Washed buckets are packaged in cleanroom grade plastic bags for storage, and shipment to NADP sites. These bags were redesigned to line the interior of the sample bucket to prevent the sample from contacting the bucket. Bench testing was performed at the NADP Program Office in Champaign Illinois. Field testing was performed at the NADP NTN site at Bondville, Illinois and at the USGS test site in Arvada, Colorado. Sampling done at the Bondville site used the standard Aerochem Metrics (ACM) collector. Sampling done at the Arvada site used the N-CON bucket collector.

Testing was performed in pairs, to allow comparison between the standard sampling protocol using the 3.5 gallon bucket, and the bag-lined bucket. QA bucket rinse samples were processed for weeks during which no precipitation occurred to compare contamination potential for each protocol.

Preliminary results suggest similar collection efficiencies for the two sampling protocols. Concentrations for all NTN and AIRMoN analytes, pH, and conductivity are similar as well.

## Coastal and Marine Mercury Ecosystem Research Collaborative (C-MERC)

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Most human exposure to mercury in the U.S. derives from the consumption of marine fish and shell fish, yet many important uncertainties and gaps exist in our understanding of the sources of methylmercury in marine ecosystems and the pathways to human and wildlife exposure. The Coastal and Marine Mercury Ecosystem Research Collaborative (C-MERC), sponsored by the Dartmouth College Toxic Metals Superfund Research Program, has convened a team of scientists and stakeholders to elucidate key processes related to the inputs, cycling and trophic transfer of mercury in marine ecosystems. The C-MERC effort has resulted in a series of papers on the state of the knowledge with respect to mercury in marine ecosystems. The papers examine mercury sources, transport, bioavailability and effects in six marine ecosystems (open ocean, Arctic Ocean, Gulf of Mexico, Gulf of Maine, San Francisco Bay, tropical oceans), mercury policy issues in the context of an international treaty, mercury-nutrient linkages in marine ecosystems, and mercury exposure and health effects. Inputs of mercury occur due to direct emissions from human activities (e.g., incineration, electric utilities, mining), re-emissions of previously deposited mercury (e.g., biomass burning, photovolatilization, soil respiration) and natural release of mercury from geogenic sources (e.g., volcanoes, soil). Mercury emissions are generally deposited to the Earth's surface as inorganic mercury (ionic, elemental). In reducing environments (wetlands, sediments, water column), ionic mercury can be converted to methylmercury, the form that is readily transferred up the food chain resulting in exposure to wildlife and humans. The diverse marine systems studied in C-MERC exhibit variable pathways of inorganic and methylmercury supply. For inorganic mercury, dominant inputs can be derived from direct atmospheric deposition, riverine inflows or inputs from the open ocean. Major inputs of methylmercury can include supply from the open ocean, riverine inflows or internal methylation from the water column or coastal sediments. These different pathways of mercury supply suggest that marine ecosystems will be highly variable in their response times to changes in atmospheric mercury emissions and deposition, and that open ocean food webs from which much of our seafood is harvested will likely benefit from decreases in atmospheric emissions. Exposure of mercury can occur through two categories of consumers: the general consumer who largely obtains fish from global sources (e.g., tuna, pollack) and the local consumer who consumes local fish. Understanding contrasting pathways of mercury transport and exposure will be central to the development of effective policies to limit mercury exposure and to the accurate interpretation of monitoring results.

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## CITIZEN SCIENTISTS STUDY MERCURY IN DRAGONFLY LARVAE AT NATIONAL PARKS

Colleen Flanagan and Dr. Sarah Nelson

Mercury is a globally distributed contaminant that can harm human and wildlife health, and threaten resources the National Park Service (NPS) is charged with protecting. Due in part to emissions and long-range transport from coal-burning power plants, even remote national park environments receive mercury deposition from the atmosphere. In an effort to increase public awareness regarding the mercury issue, a citizen science project was expanded in 2012 to collect dragonfly larvae for mercury analysis in national parks. Dragonfly larvae (*Odonata: anisoptera*) can serve as indicators of ecosystem health by characterizing the risk and potential trophic transfer of mercury. These aquatic macroinvertebrates are long-lived before emerging as adult dragonflies, widespread across the U.S., predatory, important prey for fish species, they reflect the mercury sensitivity of a specific watershed, and they are relatively easy to collect.

Fourteen national parks across the U.S. are participating in the initial effort: Acadia (ME), Big Cypress (FL), Cape Cod (MA), Channel Islands (CA), Denali (AK), Great Smoky Mountains (NC/TN), Mammoth Cave (KY), Marsh-Billings Rockefeller (VT), North Cascades (WA), Rocky Mountain (CO), Saint Croix (WI/MN), Saint-Gaudens (NH), Santa Monica Mountains (CA), and Zion (UT). This citizen science project engages students, teachers, and visitors in national parks. Moreover, the project supports the "Call to Action," the NPS Centennial Initiative, by connecting people to parks and advancing the educational mission.

Preliminary data indicate that there are significant differences among sites, even within a park, suggesting that these bio-sentinels could be useful in describing fine-scale differences in mercury risk. For example, in two ponds at Acadia National Park where marked differences in fish mercury were reported in earlier research, dragonfly larvae mercury followed the same pattern; dragonfly larvae mercury was approx. two times greater in the pond with higher-mercury fish (dragonfly mercury mean $\pm$ SD=237 $\pm$ 30 ppb, wet weight) as compared to the pond with lower-mercury fish (dragonfly larvae mean $\pm$ SD=111 $\pm$ 45 ppb, wet weight).

In addition to increasing public awareness about mercury issues, this study provides baseline data to better understand the spatial distribution of mercury contamination in national parks. It expands the geographic scope of research previously conducted by scientists and provides data that can be compared across parks. Funding options for future years are currently being explored.

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## Surface water quality trends from the TIME/LTM programs

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Surface water chemistry provides direct indicators of the potential effects of anthropogenic impacts, such as acidic deposition and climate change, on the overall health of aquatic ecosystems. Long-term surface water monitoring networks provide a host of environmental data that can be used, in conjunction with other networks, to assess how water bodies respond to stressors and if they are potentially at risk (e.g., receiving pollutant deposition beyond its critical load). Two EPA-administered monitoring programs provide information on the effects of acidic deposition on headwater aquatic systems: the Temporally Integrated Monitoring of Ecosystems (TIME) program and the Long-Term Monitoring (LTM) program. These programs were designed to track the effectiveness of the 1990 Clean Air Act Amendments (CAAA) in reducing the acidity of surface waters in: New England, the Adirondack Mountains, the Northern Appalachian Plateau, and the Ridge and Blue Ridge Provinces. LTM water quality trends from 1990 to 2010 indicate significant decreasing concentrations of sulfate in most monitored sites in the Northern Appalachian Plateau, Adirondack Mountains, and New England regions, but in only 31% of streams monitored in the Ridge and Blue Ridge Provinces. Most sites exhibited constant or only slightly declining nitrate concentrations over the same time period. Acid Neutralizing Capacity (ANC) levels improved at over 50% of sites in the Adirondacks and Northern Appalachian Plateau, but few sites showed increases in New England or the Ridge and Blue Ridge Provinces. The ANC of northeastern TIME lakes was also evaluated from 1991 to 1994 and 2006 to 2008. The percentage of lakes with ANC values below 50  $\mu\text{eq/L}$ , lakes of acute or elevated concern, dropped by about 7%. Critical loads were calculated for TIME lakes in the Adirondack Mountains and TIME streams in the Ridge and Blue Ridge Provinces. For the period from 1989 to 1991, before implementation of the CAAA, 45% of lakes and 41% of these streams received levels of combined sulfur and nitrogen deposition that exceeded the critical load. For the 2006 to 2008 period, 30% of lakes and 31% of streams were in exceedance. Information from long-term monitoring has shown that emission reductions, have resulted in improved environmental conditions and increased ecosystem protection. However, despite some ecological recovery, lakes and streams in these regions remain at risk due to current acid deposition levels. The TIME/LTM programs, along with other monitoring networks, will continue to monitor surface water trends for effects of acid deposition and other anthropogenic impacts.

## Large-scale Monitoring Data Inventory Projects Sponsored by US Geological Survey

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Two related efforts are being undertaken by the US Geological Survey (USGS) of the US Department of the Interior (DOI) to consolidate information and data from monitoring networks over large geographic areas in the US – one at a regional scale and one at a national scale

*Development of a Geospatial Inventory of Environmental Monitoring Resources in the Southeast: DOI Southeast Climate Science Center.* The DOI Southeast Climate Science Center (SECSC), based at NC State University, is initiating a project with the objective to develop an inventory of physical, chemical, and biological data from terrestrial, aquatic (including coastal), and atmospheric monitoring networks in the southeast region. A primary focus will be the development of a geospatially-searchable portal for metadata about existing monitoring networks. The region of interest is the region encompassed by the SECSC and the Southeast Association of Fish and Wildlife Agencies. The metadata portal will provide links to data useful for science being conducted as part of the Science Plan for the SECSC, which is designed to provide physical and biological research, ecological forecasting, and multi-scale modeling for Southeastern resource managers. The portal will also provide a centralized location for information and links to data relevant to adaptive management efforts and decision-support tools developed in conjunction with Landscape Conservation Cooperatives, and to other conservation partners.

*A National Compilation and Inventory of Water-Quality Monitoring Data: USGS National Water Quality Assessment Program.* Specific objectives of this project are to compile readily available water-quality data from federal, state, and regional government agencies, and non-governmental organizations; inventory, catalogue, and summarize these data; and determine the suitability of these data for addressing key environmental issues, such as energy development, nutrient enrichment, land use effects, and climate change. Water quality data types targeted in the compilation include surface-water and groundwater chemistry, aquatic biota, and streamflow. This compilation will be used initially to perform an inventory describing current and historic water-quality monitoring data available to address regional- to national-scale water resource issues, and to delineate available data relevant for several current or planned projects, such as the National Network of Reference Watersheds and Monitoring Sites and "Cycle 3" (2013 to 2023) of the USGS National Water Quality Assessment Program. The USGS will use this data compilation in collaboration with other agencies involved with multi-state water-policy issues, assessments, and planning. Data from 32 states in the northeast, southeast, and midwest U.S. are currently being compiled, with the intent to expand to national coverage.

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## Metro East Community Air Quality Study

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Illinois State Water Survey's Central Analytical Laboratory (ISWS/CAL) of the Prairie Research Institute at the University of Illinois at Urbana-Champaign performs measuring gaseous ambient nitrogen dioxide (NO<sub>2</sub>) and sulfur dioxide (SO<sub>2</sub>) concentrations in Metro East St-Louis region. This study is a part of Metro East Community Air Project, which is sponsored by Action Research Illinois, at the University of Illinois.

Passive type diffusion Radiello™ samplers, adsorbing NO<sub>2</sub> and SO<sub>2</sub> onto triethanolamine (TEA) are deployed at 25 locations for one week every other month. After transporting to CAL, samplers are extracted, and the extracts are then analyzed for nitrite (NO<sub>2</sub><sup>-</sup>) and sulfite (SO<sub>3</sub><sup>2-</sup>). NO<sub>2</sub><sup>-</sup> is directly determined by Flow Injection Analysis (FIA); SO<sub>3</sub><sup>2-</sup> is oxidized to SO<sub>4</sub><sup>2-</sup>, and then the concentration of SO<sub>4</sub><sup>2-</sup> is determined by Ion Chromatography (IC).

A number of measures (sample triplicates, travel blanks, preparation blanks, quality control analytical blanks, etc.) are provided for producing quality assured data. Preliminary results are presented.

## Nitrogen and Sulfur Atmospheric Deposition on Whiteface Mountain, 1985-2010

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Controls of SO<sub>2</sub> and NO<sub>x</sub> emissions due to the 1990 Amendments of the Clean Air Act and the U.S. Environmental Protection Agency Nitrogen Budget Program have resulted in marked decreases of atmospheric SO<sub>4</sub><sup>2-</sup> and NO<sub>3</sub><sup>-</sup> deposition in the eastern United States. Because of the high elevation, high rainfall and shallow soil, the forest ecosystems of Whiteface Mountain, Adirondack Park, New York are particularly sensitive to acid deposition. Acid anions in wet and cloud water deposition were compared before and after 2000 to assess the relative effectiveness of emission controls. NH<sub>4</sub><sup>+</sup>, NO<sub>3</sub><sup>-</sup> and SO<sub>4</sub><sup>2-</sup> ion data from the National Atmospheric Deposition Program were used to quantify annual nitrogen and sulfur wet deposition at 610m on Whiteface Mountain from 1985 to 2010. From 1985 to 1999, the average annual N and S total wet deposition were 4.80 kg N ha<sup>-1</sup> and 5.94 kg S ha<sup>-1</sup>, respectively. Between 2000 and 2010, wet N and S deposition averaged 4.06 kg N ha<sup>-1</sup> and 3.96 kg S ha<sup>-1</sup>, decreases of approximately 15% and 33%, respectively. In addition to measured wet deposition, cloud deposition contributes significantly to ion fluxes at Whiteface Mountain. The magnitude of cloud water deposition was greater than wet deposition, averaging 7.29 kg N ha<sup>-1</sup> and 7.96 kg S ha<sup>-1</sup> at 1150m annually from 2001-2010. Both N and S concentrations in cloud water have similar rates of decline as wet deposition since the implementation of emission controls.

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## Total Phosphorus: Significant or Not?

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Phosphorus can be present in water samples in at least three forms: orthophosphate, acid-hydrolysable phosphate and organic phosphorus. Organic phosphorus is changed to inorganic by bacterial action. Orthophosphate can be measured directly and the other two forms must be converted to orthophosphate prior to testing. Total phosphorus measurements in precipitation samples from the National Atmospheric Deposition Network (NADP) were determined by flow injection analysis from samples received in February 2011 to present. Precipitation samples for this study were collected from the Atmospheric Integrated Monitoring Network (AIRMoN). These samples are collected within a 24 hour precipitation event, are immediately refrigerated, and remain chilled during shipment to the NADP Central Analytical Laboratory (CAL) in Champaign, IL.

These samples were tested by the CAL for Orthophosphate and Total Phosphorus within one week of arrival at the CAL. A second set of samples were collected at Bondville, IL (IL11) site as a special study from February 2011 till October 2011. These samples were collected side by side with the AIRMoN sample at this site but the sample was collected directly into a refrigerated compartment and never allowed to come to seasonal temperature. Only total phosphorus was analyzed on the special study samples. Filtered vs. unfiltered samples were also measured to identify any differences.

A second set of precipitation samples were also analyzed for total phosphorus. These samples were collected and kept frozen by The Canadian Air and Precipitation Monitoring Network (CAPMoN), in Toronto, Canada. The samples were shipped to the CAL in coolers and analyzed for total phosphorus and orthophosphate.

The total phosphorus method detection limit was determined to be 0.005 mg/L. Total conversion to orthophosphate was determined by using two quality control standards every six samples during analysis. The recovery for a 0.025 mg/L trimethyl phosphate (TMP) was found to be 96% and a 0.050 mg/L sodium tripolyphosphate (3P) was found to be 100%. Seasonal data from this study will be presented as well as site specific total phosphorus vs. orthophosphate concentrations throughout the year.

## The Effects of Gaseous Ozone and Nitric Acid Deposition on Two Crustose Lichen Species From Joshua Tree National Park

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Lichens lacking root systems, are dependent on atmospheric deposition for the majority of their water and nutrients. This reliance however, makes lichens highly sensitivity to atmospheric conditions and pollutants. It is this sensitivity that often allows lichens to be used as bioindicators for air quality. While studies have shown that epiphytic (tree dwelling) lichens show much promise as bioindicators, virtually nothing is known about crustose (rock dwelling) lichens. The atmospheric pollutants ozone (O<sub>3</sub>) and nitric acid (HNO<sub>3</sub>) are two major pollutants found within the Los Angeles Basin. Ozone has been shown to not significantly affect lichen; however HNO<sub>3</sub> has not been extensively studied, and seems to be phytotoxic to some lichen. Both of these pollutants are deposited downwind from the L.A. basin into Joshua Tree National Park. A gradient of these pollutants in the Park has been demonstrated by previous research. We studied two lichen of particular interest from Joshua Tree National Park, *Lobothallia praeardiosa* (Nyl.) Hafellner, and *Acarospora socialis* H. Magn., both of which are crustose species with unknown sensitivities to ozone, as well as unknown and hypothesized tolerances to nitrogen compounds, respectively. Little research exists for either species, possibly because of how difficult it is to work with crustose lichen. This research attempts to expand the background knowledge of these species by fumigating them with varying levels of ozone and nitric acid, to ascertain physiological responses to the pollutants. Because of the lack of knowledge, it is difficult to predict their responses to the fumigations, however based on previous research: it is fair to postulate that both species may not be affected during the O<sub>3</sub> fumigation exposures. Additionally, based on *Acarospora*'s nitrophilous response to nitrogen pollutants, it is postulated that *Acarospora* will exhibit a positive response to the HNO<sub>3</sub> fumigation, when compared to *Lobothallia*'s response, however, since nitric acid has been shown to be phytotoxic, it is postulated that at higher fumigant exposure treatments, both species will exhibit negative physiological responses. To determine physiological responses, chlorophyll fluorescence, dark respiration, and microscopic imaging will be measured throughout the fumigations. Lichen washes and ambient nitrogen deposition samplers placed in the park will be used to determine the deposition levels the lichen are experiencing before and during the fumigations. Overall, this research seeks to broaden the background of these two unstudied California crustose species' sensitivity to ozone and nitric acid in the hopes of using them as bioindicators in the future.

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## Table of Needs for Estimation of Total Deposition

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The total deposition science (TDEP) committee became an official part of the National Atmospheric Deposition Program (NADP) during the Fall 2011 NADP Scientific Symposium held in Providence, Rhode Island. The mission of the TDEP committee is to improve estimates of atmospheric deposition by advancing the science of measuring and modeling atmospheric wet, dry and total deposition of species such as sulfur, nitrogen and mercury by providing a forum for the exchange of information on current and emerging issues within a broad multi-organization context consisting of atmospheric scientists, ecosystem scientists, resource managers and policy makers.

In order to accomplish its mission statement the TDEP committee established specific charges, which include 1) support of national atmospheric monitoring networks by providing information on emerging measurement techniques, model development and uncertainties associated with these approaches, 2) identification and prioritization of knowledge gaps in the fields of measuring and modeling of atmospheric deposition, as well as 3) to encourage greater communication and collaboration between groups from different disciplines with interests in atmospheric deposition. To help address these specific charges a 'Table of Needs' was created by the committee as a communication tool in which ongoing, planned, and needed work could be summarized, prioritized and used by agencies and/or groups as justification for research proposals. The Table is a living document that is updated based on input from meeting participants as well as emerging information. The actual table presented in this poster exists in spreadsheet format to facilitate sorting of the various categories based on area of interest.

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## Biological Sensors for Atmospheric Nitrogen Deposition

Amanda James, James Sickman, and Mark Fenn

The Integrated Total Nitrogen Input (ITNI) method is a technique for evaluating nitrogen deposition by utilizing plants as collection interfaces. The ITNI method employs a plant-liquid-sand system (PLS system) in which a plant is hydroponically grown in silica sand and labeled with  $^{15}\text{N}$  tracer while growing in a greenhouse. After plants are labeled, they are deployed into the environment where the  $^{15}\text{N}$  tracer in the plant tissues is diluted as a result of atmospheric nitrogen deposition input via gaseous, leaf and root uptake. At the end of the sampling period, all components of the plant and system are harvested and analyzed on a mass spectrometer to determine the degree of dilution of the tracer. The  $^{15}\text{N}$  values obtained will be incorporated into a mass balance equation that accounts for the total deposition occurring on the PLS system surfaces and yields the total nitrogen uptake from the atmosphere. In this study, we will employ Coastal Sage Scrub (CSS) species, a declining native California plant assemblage, to determine total nitrogen deposition occurring in the Inland Empire of Southern California. Traditional nitrogen deposition collection devices such as throughfall and ion exchange resins will be co-located with the ITNI PLS systems to compare and assess the accuracy of such traditional collectors. We will also be simultaneously investigating prominent invasive species to determine, by rate of isotope dilution, if nitrogen deposition is assimilated more readily in invasives than natives. This will explore the notion that increased nitrogen deposition rates to CSS assemblages increase invasive species proliferation and subsequent displacement of native CSS species. Previously calculated ecosystem critical loads of nitrogen deposition will be evaluated relative to the ITNI deposition rates. CSS and invasive species specific nitrogen deposition rates will be determined and compared with relative isotope dilution rates within the respective PLS systems. Lastly, isotope dilution data will be constructed into a gradient map for comparison against existing deposition data in California.

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## Regional, Spatial, and Temporal Errors in NADP Deposition Maps

Brian Kerschner and Robert Larson  
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The National Atmospheric Deposition Program (NADP) publishes maps that depict annual average concentration and deposition values of analytes present in precipitation. Concentration maps are produced using a standard inverse distance weighted (IDW) spatial interpolation model. A precipitation surface is generated by combining NADP station data with higher resolution data from the PRISM<sup>1</sup> model. A procedure was developed to smoothly blend the NADP data with the PRISM data to create a single precipitation surface.

A deposition surface is generated for each analyte by combining the precipitation surface with the concentration surface.

The resulting output, as with any model, provides a best estimate of wet deposition, but also contains model errors. An understanding of the errors is essential for proper interpretation of the maps.

This poster provides an overview of spatial interpolation errors, specifically the root mean square error (RMSE) of NADP wet deposition maps. The RMSE's are analyzed for all concentration and deposition analytes from 1985-2010. Spatial and temporal trend plots visualize how the errors change over time and in different geographic regions of the country.

<sup>1</sup>PRISM Climate Group, Oregon State University, <http://prism.oregonstate.edu>, created 1 Oct 2011.

## A collector comparison for wet deposition at a coastal New Hampshire site

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Atmospheric deposition is quantified for various purposes such as quantifying nutrient budgets, determining critical loads for ecosystems, or assessing the potential for foliar damage from pollutants. These atmospheric inputs to ecosystems comprise a complex mixture of compounds originating from a variety of sources deposited via several mechanisms. Wet deposition should be the easiest of these processes to measure directly, but it can be affected by how the collector opens in response to precipitation. The National Trends Network of the National Atmospheric Deposition Program (NADP) historically collected weekly wet deposition using the Aerochem Metrics (ACM) precipitation collector. In 2010, a different collector, the N-CON Atmospheric Deposition Sampler was approved for use. One way these collectors differ is in the type of sensor that identifies precipitation. Recent research has suggested that the ACM collectors respond differently to precipitation than the N-CON. The goal of this project was to compare the chemistry of wet deposition events in the two collectors at a single site for a year. We examined several commonly measured components of precipitation (ammonium, nitrate, sulfate, and chloride) that differ in their origin and the chemical properties in the atmosphere. We also evaluated differences in dissolved organic carbon (DOC) concentrations, which have not previously been measured in other collector comparisons. Further, this coastal site is exposed to more marine influence than other previously examined sites. In general, the differences between collectors were most prominent for low precipitation events. Across all events, the concentration in the N-CON was still significantly higher for ammonium, sulfate, and nitrate, but not for chloride and DOC. Similarly, the volume weighted mean concentration was higher for the N-CON for ammonium, sulfate, and nitrate, but not for chloride or DOC. The less consistent difference between collectors for DOC and chloride may reflect the greater marine influence at this site. As collector comparisons have been done at relatively few sites, the reported differences among solutes in the magnitude of collector effects cannot be ascribed to random variation or to real site-to-site differences in atmospheric chemical and physical processes. Rather, the differences among collectors may be highlighting the difficulty in distinguishing between wet and dry deposition. Therefore, better measurements of total deposition and dry deposition would minimize the importance of variability among collector types.

## Cloud and Aerosol Ammonium Concentrations on Mount Washington, NH (1,540 m)

Georgia L. D. Murray<sup>a</sup>, Kenneth Kimball<sup>a</sup>, L. Bruce Hill<sup>b</sup>, Kathleen C. Weathers<sup>d</sup>

Atmospheric acidity and sulfate concentrations have declined steeply in the US due to the 1990 Clean Air Act Amendments (CAAA) and other more recent CAA emission regulations. From 1990 to 2011, national sulfur dioxide emissions declined by 70%, nitrogen oxide emissions by 48%. Yet ammonium emissions have changed little since 1990 (Source: National Emissions Inventory\*). A multi-decade summertime cloud and aerosol chemistry dataset from the Lakes of the Clouds (LOC) site on Mount Washington, NH (1,540 m asl) reflects these emission changes with declines in sulfate in aqueous and aerosol phases. Acidity has also declined, however the relative amount of ammonium has increased with associated measured sulfate. Regression analysis of samples from pre and post 1995, e.g. implementation of the 1990 Clean Air Act Amendments (CAAA), showed that LOC site molar ratio of ammonium to sulfate in cloud water has increased from 0.77 to 1.08 while aerosol ratios have changed from 0.98 to 1.22. Changes were also observed in lower elevation aerosol records pre and post CAAA.

Cloud and rain water summer annual median concentrations, from 1996-2010, also show changes in ammonium levels relative to other ions. Median cloud water ammonium concentrations transition over the record from relatively lower (1996-1999), to near equal (2000-2004), and then exceeding (2005-2010) hydrogen concentrations. In rainfall median ammonium and nitrate concentrations are similar at LOC from 1996 to 2004 and then ammonium increases while nitrate does not from 2005 to 2008. All ions dipped dramatically in 2009, which was a very wet summer, but then rebounded upward in 2010.

A comparison of 72-hour back trajectories, using NOAA's HYSPLIT and North American Regional Reanalysis data, between relatively acidic vs. neutralized cloud and aerosol events measured at LOC will be presented. Initial results demonstrate that high sulfate-ammonium dominated occur when air masses have relatively longer flow paths from ammonia emission source regions.

\* NEI 2008v2 at the Tier 1 level <http://www.epa.gov/ttn/chie1/trends/>

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## NADP SENSOR STUDY

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In mid-2012 the National Atmospheric Deposition Program (NADP) began a field study comparing precipitation sensors used in its wet-deposition networks. The goal of the study is to identify differences between sensors in terms of detecting the onset of precipitation and duration of the precipitation event. The study includes both grid/plate type sensors and optical sensors. Testing focuses on precipitation sensors used in the NADP networks.

The study is being conducted at the NADP site in Bondville, Illinois. Sensors are configured in a grid, with each grid cell being approximately 13 ft by 13 ft (4m by 4m). The height of each sensor from the ground ranges from 4 ft to 5 ft (1.2m to 1.5m), allowing for changes in elevation.

NADP precipitation sensors used in the study are configured in pairs. This will help define the variability of a particular sensor. Placement of the sensors was determined through double randomization. Grid locations and individual sensors were assigned numeric values using a random number generator. Numeric values were then matched.

Results of the study will provide insight into the following questions

- Which settings (number of droplets per interval of time and switch-off delay) are most appropriate for operating the optical sensors?
- What impact does the precipitation type have on the operation of the sensor?
- How sensitive is each sensor type to blowing snow and mist?

It is anticipated that the sensor study at H.11 will continue through 2013 in order to capture differences with different precipitation types.

## In-Canopy Measurements of Ozone and Other Gases and Particles at Maine's Howland Research Forest

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Dr. Greg Beachley, U.S. Environmental Protection Agency, CAMD  
Kevin Mishoc, AMEC, Inc. Newberry, FL

In September 2011, the Clean Air Status and Trends Network (CASTNET) began a collaborative effort with Ameriflux to investigate atmospheric to vegetative exchanges of ozone and sulfur and nitrogen species at the Howland Research Forest Ameriflux site in Maine. The forest is comprised of mature, lowland evergreen trees aged 40 to 160 years with a local canopy height of 20 meters. Measurements taken at the site consist of hourly ambient ozone concentrations sampled at eight levels throughout and above the evergreen canopy and weekly integrated ambient concentrations of gases and particles from CASTNET filter packs located above and below the canopy. Design for the ozone system centered on the use of a single ozone analyzer and site transfer standard in conjunction with a solenoid system to allow for all eight levels to be measured with a residence time less than 20 seconds using the same analyzer. Quality assurance and analyzer performance is checked daily with calibration gas delivered through-the-probe at an inlet height of 23.5 meters. The checks show no evidence of line loss. Hourly ozone data collected thus far have shown evidence of episodic, nighttime negative concentration gradients with decreasing sampling height that may be indicative of potential deposition and scavenging mechanisms occurring within the canopy. These losses were compared with meteorological data to provide insight as to the degree of these phenomena as opposed to a gradient due to poor mixing within the canopy.

Weekly-integrated ambient concentrations measured with the filter pack support these observations having below canopy concentrations of approximately 60% and 64% of above-canopy concentrations for sulfur dioxide and total nitrate (including gaseous nitric acid), respectively. Above and below-canopy concentrations for concentrations of particulate matter components (i.e. total ammonium and sulfate) show much less difference, which may be indicative of slower deposition rates compared with those of the gaseous species. In addition, both hourly ozone and weekly filterpack data are collected at a nearby (5 kilometers) CASTNET site where measurements occur in a clearing at 10 meters. For the first quarter of 2012, concentrations of sulfur dioxide and total nitrate at this site were ~10% lower than those of the above-canopy filter pack ( $R^2=0.96$ ). Particulate sulfate and ammonium concentrations were 2% ( $R^2=0.99$ ) and 8% ( $R^2=0.98$ ) lower, respectively. Hourly ozone concentrations were ~9% lower than above-canopy measurements ( $R^2=0.93$ ), but more investigation is needed as there is evidence of a diminished episodic nighttime loss consistent with that described for the forest canopy. Future work will include comparison of CASTNET data with AmeriFlux carbon dioxide and flux data and the possibility the installation of similar equipment at other AmeriFlux sites.

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## Evaluation and Application of the CALPUFF Model for Evaluating Deposition Impacts to Support Critical Load Analyses on a Local Scale

John Sherwell, Surya Ramaswamy and Mark Garrison

The Maryland Power Plant Research Program (PPRP) has been involved with evaluating impacts of regional sources of air emissions on air quality in Maryland and effects on the Chesapeake Bay for many years. The CALPUFF model is a useful tool for conducting impact analyses of regional sources on nutrient loading to the Bay and for specific smaller water bodies. The Lagrangian form of the model is readily adaptable to "scale down" impacts to receptor areas that are no more than a few hundred meters in size; thus CALPUFF is useful in assessing impacts to sensitive lakes, streams, and coastal areas with a high degree of resolution. A concern with CALPUFF is that its underlying science is not as complete as contained in more advanced eulerian grid models such as CMAQ and CAMx. Since CALPUFF provides a resolution not achievable by the larger grid models, its use in conjunction with the grid models would seem to be a worthy objective. As a step towards this end, PPRP has conducted evaluations of CALPUFF predictions compared to measurements of nitrate deposition and concentrations of species that contribute to deposition (e.g. particulate nitrate and nitric acid), obtained from national measurement networks including CASTNET, IMPROVE, and NADP/NTN stations. This paper will provide a summary of these evaluations, illustrations for using CALPUFF to assess critical loads for selected areas, and provide insights into some possible steps to further harmonize this Lagrangian approach with the more complex grid models.

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## Dose Response Relationships Associated with the Acidification of Freshwater Lakes and Streams

Kaylyn Siporin<sup>1</sup>, Laura Datko-Williams<sup>1</sup>, Jean-Jacques Dubois<sup>2</sup>, Meredith Lassiter<sup>2</sup>, and Tara Greaver<sup>2</sup>

Secondary national ambient air quality standards (NAAQS) were established to protect public welfare (e.g. soils, water, crops, vegetation, animals, wildlife, weather, visibility, and climate). The current secondary NAAQS for oxides of nitrogen ( $\text{NO}_x$ ) is an annual average of nitrogen dioxide not to exceed 0.053 ppm, and for oxides of sulfur ( $\text{SO}_x$ ), a 3-hour average of sulfur dioxide not to exceed 0.5 ppm more than once per year. These standards are designed to protect against gas-phase effects and are rarely exceeded. However, damaging ecological effects of  $\text{NO}_x$  and  $\text{SO}_x$  also occur through acidifying deposition. Those deposition effects are widespread in the U.S. and include acidification of aquatic ecosystems through terrestrial deposition, which is followed by leaching of  $\text{NO}_3^-$  and  $\text{SO}_4^{2-}$  from soil to surface waters.

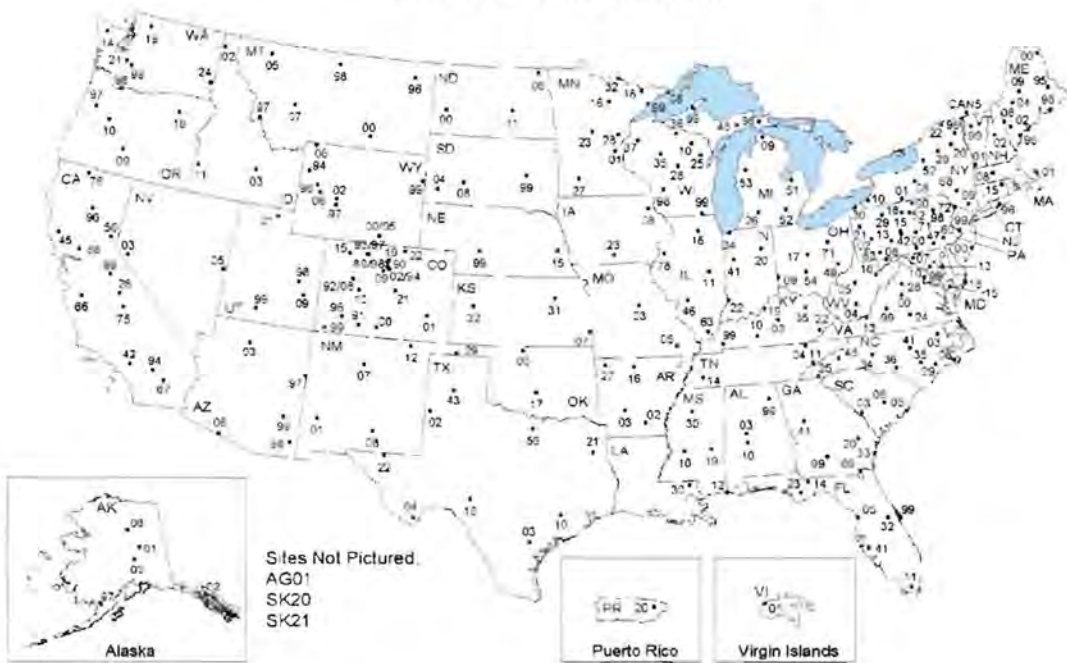
We have assembled an inventory of published dose-response data and relationships that can be or have been used to characterize acidification in freshwater lakes and streams. The relationships of interest are among water quality factors (biogeochemical indicators) and responses of biota to changes in those factors (biological indicators). Examples of biogeochemical indicators include  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ , base cations, acid neutralizing capacity (ANC), inorganic aluminum, and pH. Examples of biological indicators include presence/absence of organisms, survival, growth, reproduction, and biodiversity. In the studies inventoried to date, pH and mortality were the most common indicators evaluated. This research was supported in part by an appointment to the Research Participation Program for the U.S. EPA, Office of Research and Development, administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the U.S. Department of Energy and EPA. The study was reviewed by the National Center for Environmental Assessment, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the view and policies of the EPA, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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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, 2012

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Alabama</b>				
AL03	Centerville	MDN	Atmospheric Research & Analysis, Inc	02/11
AL10	Black Belt Research & Extension Center		US Geological Survey	08/83
AL99	Sand Mountain Research & Extension Center	AMoN	Tennessee Valley Authority	10/84
<b>Alaska</b>				
AK01	Poker Creek		USDA Forest Service	12/92
AK02	Juneau		USDA Forest Service/University of Alaska Southeast	06/04
AK03	Denali NP - Mount McKinley		National Park Service - Air Resources Division	06/80
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
<b>Argentina</b>				
AG01	Laurenti-MAR	NTN	PROMAR- Centro de Zoologia Aplicada UNC	10/11
<b>Arizona</b>				
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-CAMD	02/99
AZ99	Oliver Knoll		US Geological Survey	08/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Arkansas</b>				
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
<b>California</b>				
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
<b>Colorado</b>				
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-CAMD	12/87
CO09	Kawaneechee Meadow		Grand County Water Information Network	07/12
CO10	Gothic		US Environmental Protection Agency-CAMD	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		NSF-Shortgrass Steppe LTER/Colorado State University	05/79
CO89	Rocky Mountain National Park-Loch Vail		USGS/Colorado State University	09/09
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-CAMD	01/88
CO93	Buffalo Pass - Dry Lake		USDA Forest Service	10/86
CO94	Sugarloaf		US Environmental Protection Agency-CAMD	11/86
CO96	Molas Pass	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
<b>Connecticut</b>				
CT15	Abington	AMoN	US Environmental Protection Agency-CAMD	01/99
<b>Florida</b>				
FL03	Bradford Forest		US Environmental Protection Agency-CAMD	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		US Environmental Protection Agency-CAMD	01/99
FL32	Orlando		Seminole County Public Works Department	12/05
FL41	Verna Well Field		US Geological Survey	08/83
FL99	Kennedy Space Center		NASA/Innovative Health Applications, LLC	08/83
<b>Georgia</b>				
GA09	Okefenokee NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	06/97
GA20	Bellville		US Environmental Protection Agency-CAMD	04/83
GA33	Sapelo Island	MDN	NSF/UGA, & GA Dept of Natural Resources	11/02
GA41	Georgia Station	AMoN	Atmospheric Research & Analysis, Inc.	10/78
GA99	Chula		US Geological Survey	02/94
<b>Idaho</b>				
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
<b>Illinois</b>				
IL11	Bondville	AIRMoN/ MDN/AMoN	US Environmental Protection Agency-CAMD	02/79
IL18	Shabbona		SAES-University of Illinois	05/81
IL46	Alhambra	AMoN	US Environmental Protection Agency-CAMD	01/99
IL63	Dixon Springs Agricultural Center		SAES-University of Illinois	01/79
IL78	Monmouth		US Geological Survey	01/85
<b>Indiana</b>				
IN20	Roush Lake		US Geological Survey	08/83
IN22	Southwest Purdue Agriculture Center		US Geological Survey	09/84
IN34	Indiana Dunes NL	MDN	National Park Service - Air Resources Division	07/80
IN41	Agronomy Center for Research and Extension		SAES-Purdue University	07/82
<b>Iowa</b>				
IA08	Big Springs Fish Hatchery		US Geological Survey	08/84
IA23	McNay Memorial Research Center		US Geological Survey	09/84
<b>Kansas</b>				
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

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Kentucky</b>				
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	Litley Cornett Woods		US Geological Survey	09/83
KY35	Clark State Fish Hatchery		US Geological Survey	08/83
KY99	Mulberry Flats		TVA/Murray State University	12/94
<b>Louisiana</b>				
LA30	Southeast Research Station		US Geological Survey	01/83
<b>Maine</b>				
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 - CAMD	03/02
ME08	Glead		US Geological Survey	09/99
ME09	Greenville Station	MDN	EPA/Maine Dept of Environmental Protection	11/79
ME96	Casco Bay - Wolfe's Neck Farm	MDN	EPA Maine Dept of Environmental Protection	01/98
ME98	Acadia NP - McFarland Hill	MDN	National Park Service - Air Resources Division	11/81

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Maryland</b>				
MD07	Catoctin Mountain Park		National Park Service - Air Resources Division	05/03
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
<b>Massachusetts</b>				
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
<b>Michigan</b>				
MI09	Douglas Lake		SAES-Michigan State University	07/79
MI26	Kellogg Biological Station		SAES-Michigan State University	06/79
MI48	Seney NWR - Headquarters	MDN	US Fish & Wildlife Service - Air Quality Branch	11/00
MI51	Unionville		US Environmental Protection Agency-CAMD	01/99
MI52	Ann Arbor		US Environmental Protection Agency-CAMD	01/99
MI53	Wellston		USDA Forest Service	10/78
MI98	Raco		US Environmental Protection Agency-CAMD	05/84
MI99	Chassell		USDA Forest Service	02/83

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Minnesota</b>				
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-CAMD	11/80
MN23	Camp Ripley	MDN	US Geological Survey	10/83
MN27	Lamberton	MDN	Minnesota Pollution Control Agency	01/79
MN28	Grindstone Lake		Minnesota Pollution Control Agency	12/96
MN32	Voyageurs NP - Sullivan Bay		National Park Service - Air Resources Division	05/00
MN99	Wolf Ridge		Minnesota Pollution Control Agency	12/96
<b>Mississippi</b>				
MS10	Clinton		US Geological Survey	07/84
MS12	Grand Bay NERR	MDN/AMNet	Mississippi Department of Environmental Quality	03/10
MS19	Newton		NOAA-Air Resources Lab	11/86
MS30	Coffeeville		Tennessee Valley Authority	07/84
<b>Missouri</b>				
MO03	Ashland Wildlife Area	MDN	US Geological Survey	10/81
MO05	University Forest		US Geological Survey	10/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Montana</b>				
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
<b>Nebraska</b>				
NE15	Mead	MDN	SAES-University of Nebraska	07/78
NE99	North Platte Agricultural Experiment Station		US Geological Survey	09/85
<b>Nevada</b>				
NV03	Smith Valley		US Geological Survey	08/85
NV05	Great Basin NP - Lehman Caves		National Park Service - Air Resources Division	01/85
<b>New Hampshire</b>				
NH02	Hubbard Brook	AMoN	USDA Forest Service	07/78
<b>New Jersey</b>				
NJ00	Edwin B Forsythe NWR		US Fish & Wildlife Service - Air Quality Branch	10/98
NJ99	Washington Crossing		US Environmental Protection Agency - CAMD	08/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>New Mexico</b>				
NM01	Gila Cliff Dwellings NM		New Mexico Environment Department - AQB/EPA	07/85
NM07	Bandelier NM		National Park Service-Air Resources Division	06/82
NM08	Mayhill		US Geological Survey	01/84
NM12	Capulin Volcano NM		New Mexico Environment Department - AQB/EPA	11/84
<b>New York</b>				
NY01	Alfred		US Geological Survey	08/04
NY08	Aurora Research Farm		USDA/Cornell University	04/79
NY10	Chautauqua		US Geological Survey	06/80
NY20	Huntington Wildlife	MDN/AMNet/ AMoN	SUNY-College of Environmental Science & Forestry	10/78
NY22	Akwesasne Mohawk - Fort Covington		US Environmental Protection Agency - CAMD	08/99
NY29	Moss Lake		US Geological Survey	07/03
NY52	Bennett Bridge		US Environmental Protection Agency-CAMD	06/80
NY68	Biscuit Brook	MDN	US Geological Survey	10/83
NY96	Cedar Beach, Southold		EPA/Suffolk Dept of Health Service-Peconic Estuary Program	11/03
NY98	Whiteface Mountain		US Geological Survey	07/84
NY99	West Point		US Geological Survey	09/83

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>North Carolina</b>				
NC03	Lewiston		North Carolina State University	10/78
NC06	Beaufort	AMoN	US Environmental Protection Agency-CAMD	01/99
NC25	Coweeta	AMoN	USDA Forest Service	07/78
NC29	Hofmann Forest		North Carolina State University	07/02
NC34	Piedmont Research Station		North Carolina State University	10/78
NC35	Clinton Crops Research Station		North Carolina State University	10/78
NC36	Jordan Creek		US Geological Survey	10/83
NC41	Finley Farms		North Carolina State University	10/78
NC45	Mount Mitchell		US Environmental Protection Agency-CAMD/NCSU	11/85
<b>North Dakota</b>				
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
<b>Ohio</b>				
OH09	Oxford		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-CAMD	01/99
OH71	Wooster		US Geological Survey	09/78

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Oklahoma</b>				
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
<b>Oregon</b>				
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-CAMD	04/83
<b>Pennsylvania</b>				
PA00	Arendtsville	MDN/AMoN	US Environmental Protection Agency-CAMD	01/99
PA02	Crooked Creek Lake		Pennsylvania State University	11/00
PA13	Allegheny Portage Railroad National Historic Site	MDN	Pennsylvania State University	07/11
PA15	Penn State	AIRMoN	NOAA-Air Resources Lab/PA Game Commission	06/83
PA18	Young Woman's Creek		US Geological Survey	04/99
PA21	Goddard State Park	MDN	Pennsylvania State University	07/11
PA29	Kane Experimental Forest	MDN/AMoN	USDA Forest Service	07/78
PA30	Erie	MDN	Pennsylvania State University	07/11
PA42	Leading Ridge	MDN	SAES-Pennsylvania State University	04/79
PA47	Millersville	MDN	Pennsylvania Department of Environmental Protection	11/02
PA52	Little Pine State Park	MDN	Pennsylvania State University	07/11
PA60	Valley Forge	MDN	Pennsylvania State University	07/11

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
PA71	Little Buffalo State Park		Pennsylvania State University	07/11
PA72	Milford	MDN	USDA Forest Service	12/83
PA83	Laurel Hill State Park		Pennsylvania State University	07/11
PA90	Hills Creek State Park	MDN	Pennsylvania State University	07/11
PA98	Frances Slocum State Park		Pennsylvania State University	07/11
<b>Puerto Rico</b>				
PR20	El Verde		USDA Forest Service	02/85
<b>South Carolina</b>				
SC03	Savannah River	MDN	Savannah River Nuclear Solution	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
<b>South Dakota</b>				
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
<b>Tennessee</b>				
TN04	Speedwell		US Environmental Protection Agency-CAMD	01/99
TN11	Great Smoky Mountain NP - Elkmont	MDN	National Park Service - Air Resources Division	08/80
TN14	Hatchie NWR		Tennessee Valley Authority	10/84
<b>Texas</b>				
TX02	Muleshoe NWR		US Geological Survey	06/85
TX03	Beeville		US Geological Survey	02/84
TX04	Big Bend NP - K-Bar		National Park Service - Air Resources Division	04/80

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
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	Cañonceta	AMoN	Texas A&M University/Texas Agrilife Research	07/07
TX56	LBJ National Grasslands		US Geological Survey	09/83
<b>Utah</b>				
UT01	Logan	AMoN	US Geological Survey	12/83
UT09	Canyonlands NP - Island in the Sky		National Park Service - Air Resources Division	11/97
UT98	Green River		US Geological Survey	04/85
UT99	Bryce Canyon NP - Repeater Hill		National Park Service - Air Resources Division	01/85
<b>Vermont</b>				
VT01	Bennington		US Geological Survey	04/81
VT99	Underhill	AIRMoN MDN/AMoN	US Geological Survey	06/84
<b>Virgin Islands</b>				
VI01	Virgin Islands NP - Lind Point		National Park Service - Air Resources Division	04/98
<b>Virginia</b>				
VA00	Charlottesville		US Geological Survey	10/84
VA13	Horton's Station		Tennessee Valley Authority	07/78
VA24	Prince Edward	AMoN	US Environmental Protection Agency-CAMD	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
<b>Washington</b>				
WA14	Olympic NP - Hoh Ranger Station		National Park Service - Air Resources Division	05/80
WA19	North Cascades NP-Marblemount Ranger Stn		US Geological Survey	02/84
WA21	La Grande		US Environmental Protection Agency-CAMD	04/84
WA24	Palouse Conservation Farm		US Geological Survey	08/85
WA98	Columbia River Gorge		USDA Forest Service - Pacific Northwest Region	05/02
WA99	Mount Rainier NP - Tahoma Woods	AMoN	National Park Service - Air Resources Division	10/99
<b>West Virginia</b>				
WV04	Babcock State Park		US Geological Survey	09/83
WV05	Cedar Creek State Park		US Environmental Protection Agency-CAMD	01/99
WV18	Parsons	AMoN	USDA Forest Service	07/78
<b>Wisconsin</b>				
WI09	Popple River	MDN	Wisconsin Department of Natural Resources	12/86
WI10	Potawatomi	MDN	EPA/Forest County Potawatomi Community	06/05
WI25	Suring		Wisconsin Department of Natural Resources	01/85
WI28	Lake Dubay		Wisconsin Department of Natural Resources	06/82

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
WI35	Perkinstown	AMoN	US Environmental Protection Agency-CAMD	01/99
WI36	Trout Lake	MDN	Wisconsin Department of Natural Resources	01/80
WI37	Spooner		Wisconsin Department of Natural Resources	06/80
WI98	Wildcat Mountain		Wisconsin Department of Natural Resources	08/89
WI99	Lake Geneva	MDN	Wisconsin Department of Natural Resources	06/84
<b>Wyoming</b>				
WY00	Snowy Range		USDA Forest Service	04/86
WY02	Sinks Canyon		Bureau of Land Management	08/84
WY06	Pinedale		Bureau of Land Management	01/82
WY08	Yellowstone NP - Tower Falls	MDN	National Park Service - Air Resources Division	06/80
WY94	Grand Tetons National Park	AMoN	State of Wyoming DEQ	09/11
WY95	Brooklyn Lake		USDA Forest Service	09/92
WY97	South Pass City		USDA Forest Service/Bridger Teton NF	04/85
WY98	Gypsum Creek		USDA Forest Service/Bridger Teton NF	12/84
WY99	Newcastle		Bureau of Land Management	08/81
<b>Canada</b>				
CAN5	Frelighsburg		US Geological Survey	10/01
CAN6	Frelighsburg - Intercomparison		US Geological Survey	10/11
SK20	Cactus Lake		Saskatchewan Ministry of Environment	02/12
SK21	Hudson Bay		Saskatchewan Ministry of Environment	04/12

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, 2012

State	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Delaware</b>					
	DE02	Lewes		NOAA-Air Resources Laboratory	09/92
<b>Illinois</b>					
	IL11	Bondville	MDN/NTN/AMoN	NOAA-Air Resources Laboratory	10/92
<b>New York</b>					
	NY67	Cornell University	AMoN	NOAA-Air Resources Laboratory	09/92
<b>Pennsylvania</b>					
	PA15	Penn State	NTN	NOAA-Air Resources Laboratory	10/92
<b>Tennessee</b>					
	TN00	Walker Branch Watershed		NOAA-Air Resources Laboratory	09/92
<b>Vermont</b>					
	VT99	Underhill	MDN/NTN/AMNet	University of Vermont /NEIWPC	01/93
<b>West Virginia</b>					
	WV99	Canaan Valley Institute	AMNet/MDN	NOAA-Air Resources Laboratory	06/00

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# AMoN Map and Site Listings

## National Atmospheric Deposition Program Ammonia Monitoring Network



## National Atmospheric Deposition Program/Ammonia Monitoring Network Sites

July 31, 2012

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Alabama</b>				
AL99	Sand Mountain Research & Extension Center	NTN	US Environmental Protection Agency - CAMD	03/11
<b>Arizona</b>				
AZ98	Chiricahua	NTN	National Park Service - Air Resources Division	03/11
<b>Arkansas</b>				
AR03	Caddo Valley	NTN	US Environmental Protection Agency - CAMD	03/11
<b>California</b>				
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
<b>Colorado</b>				
CO10	Gothic	NTN	US Environmental Protection Agency - CAMD	06/12
CO13	Fort Collins	MDN	US Environmental Protection Agency - CAMD	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
<b>Connecticut</b>				
CT15	Abington	NTN	US Environmental Protection Agency - CAMD	03/11
<b>Florida</b>				
FL11	Everglades NP - Research Center	NTN/MDN	National Park Service - Air Resources Division	03/11
FL19	Indian River		US Environmental Protection Agency - CAMD	04/11

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Georgia</b>				
GA40	Yorkville	AMNet/MDN	Atmospheric Research & Analysis	12/11
GA41	Georgia Station	NTN	US Environmental Protection Agency - CAMD	06/11
<b>Idaho</b>				
ID03	Craters of the Moon NM	NTN	National Park Service - Air Resources Division	06/10
<b>Illinois</b>				
IL11	Bondville	AIRMoN/MDN /NTN	US Environmental Protection Agency - CAMD	10/07
IL37	Stockton		US Environmental Protection Agency - CAMD	04/11
IL46	Alhambra	NTN	US Environmental Protection Agency - CAMD	03/11
<b>Indiana</b>				
IN22	Southwest Purdue Agriculture Center	NTN	US Environmental Protection Agency - CAMD	06/12
IN99	Indianapolis		US Environmental Protection Agency - CAMD	10/07
<b>Kansas</b>				
KS03	Reserve	MDN	Sac and Fox Nation of Missouri	10/11
KS31	Konza Prairie	NTN	US Environmental Protection Agency - CAMD	03/11
KS98	Coffeyville	NTN	US Environmental Protection Agency - CAMD	
<b>Kentucky</b>				
KY03	Mackville	NTN	US Environmental Protection Agency - CAMD	03/11
KY98	Cadiz		US Environmental Protection Agency - CAMD	03/11
<b>Maryland</b>				
MD08	Piney Reservoir	MDN/AMNet/ NTN	State of MD/ Department of Natural Resources	08/10

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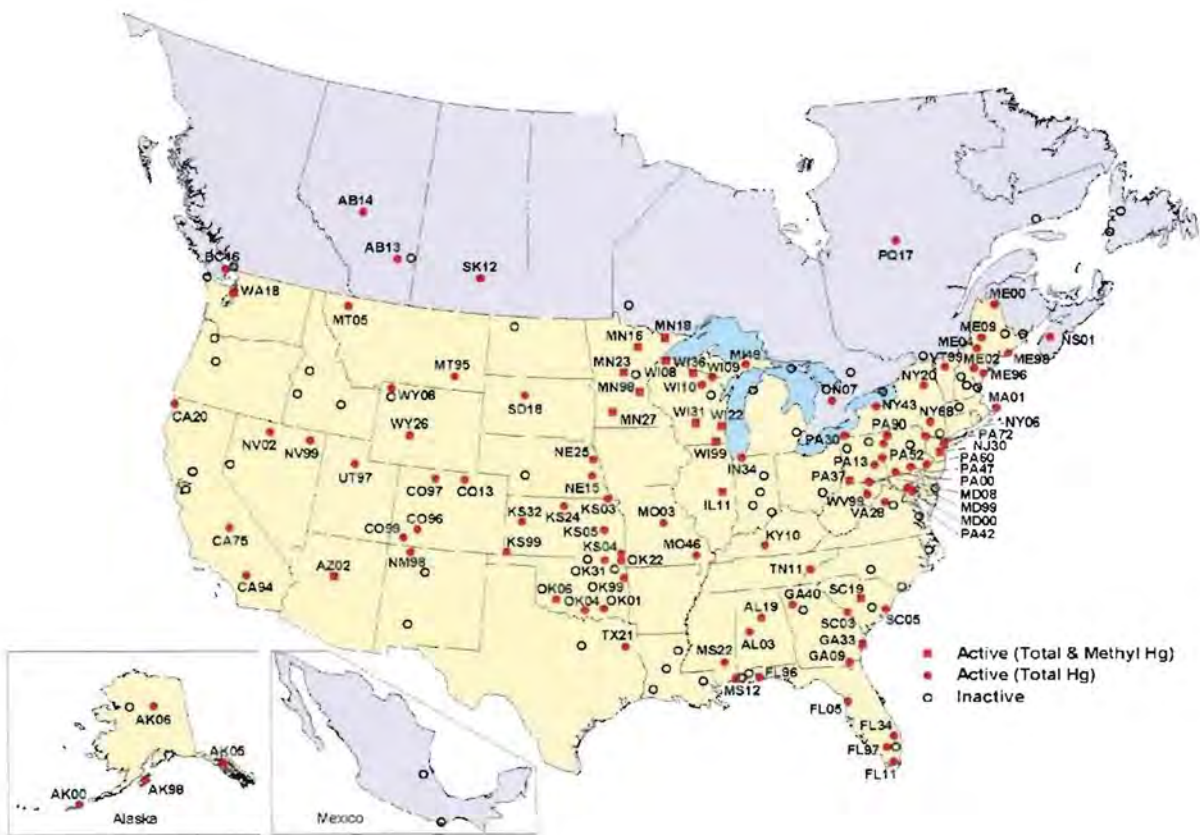
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Michigan	MD99 Beltsville	MDN/AMNet/ NTN	State of MD/ Department of Natural Resources	08/10
	M196 Detroit		US Environmental Protection Agency - CAMD	10/07
Minnesota	MN18 Fernberg	NTN/MDN	US Environmental Protection Agency - CAMD	10/07
Nebraska	NE98 Santee		US Environmental Protection Agency - CAMD	04/11
New Hampshire	NH02 Hubbard Brook	NTN	US Environmental Protection Agency - CAMD	06/12
New Jersey	NJ98 Washington Crossing CASTNET		US Environmental Protection Agency - CAMD	03/11
New Mexico	NM98 Navajo Lake	MDN	US Environmental Protection Agency - CAMD	01/08
	NM99 Farmington		US Environmental Protection Agency - CAMD	01/08
New York	NY16 Cary Institute		Cary Institute Of Ecosystem Studies	10/09
	NY20 Huntington Wildlife	MDN/AMNet/ NTN	US Environmental Protection Agency - CAMD	06/12
	NY67 Ithaca	AIRMoN	US Environmental Protection Agency - CAMD	10/07
North Carolina	NC06 Beaufort	NTN	US Environmental Protection Agency - CAMD	04/10
	NC25 Coweeta	NTN	US Environmental Protection Agency - CAMD	05/11
	NC26 Candor		US Environmental Protection Agency - CAMD	04/11
	NC30 Duke Forest		US Environmental Protection Agency - CAMD	06/08

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Ohio	OH02 Athens Super Site	AMNet	US Environmental Protection Agency - CAMD	10/07
	OH27 Cincinnati		US Environmental Protection Agency - CAMD	10/07
	OH54 Deer Creek State Park	NTN	US Environmental Protection Agency - CAMD	03/11
Oklahoma	OK99 Stilwell	MDN/AMNet	US Environmental Protection Agency - CAMD	10/07
Pennsylvania	PA00 Arendtsville	NTN/MDN	US Environmental Protection Agency - CAMD	10/09
	PA29 Kane Experimental Forest	NTN/MDN	US Environmental Protection Agency - CAMD	03/11
South Carolina	SC05 Cape Romain NWR	NTN/MDN	US Environmental Protection Agency - CAMD	10/07
Tennessee	TN01 Great Smoky Mountains NP- Look Rock		National Park Service - Air Resources Division	03/11
Texas	TX43 Cañonceta	NTN	US Environmental Protection Agency - CAMD	10/07
Utah	UT01 Logan	NTN	State of Utah	11/11
	UT97 Salt Lake City	MDN/AMNet	State of Utah	11/11
Virginia	VA24 Prince Edward	NTN	US Environmental Protection Agency - CAMD	03/11

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Washington</b>				
WA99	Mount Rainier NP - Tahoma Woods	NTN	National Park Service - Air Resources Division	03/11
<b>West Virginia</b>				
WV18	Parsons	NTN	US Environmental Protection Agency - CAMD	06/11
<b>Wisconsin</b>				
W107	Horicon Marsh		US Environmental Protection Agency - CAMD	10/07
W135	Perkinstown	NTN	US Environmental Protection Agency - CAMD	03/11
<b>Wyoming</b>				
WY94	Grand Tetons National Park	NTN	National Park Service - Air Resources Division	09/11
WY95	Brooklyn Lake		National Park Service - Air Resources Division	06/12



# MDN Map and Site Listings



## National Atmospheric Deposition Program/Mercury Deposition Network Sites

July 31, 2012

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Alabama</b>					
	AL03	Centreville	NTN	Atmospheric Research and Analysis, Inc	06/00
	AL19	Birmingham	AMNet	Atmospheric Research and Analysis, Inc	12/10
<b>Alaska</b>					
	AK00	Dutch Harbor		State of Alaska Department of Environmental Conservatio	09/09
	AK05	Glacier Bay National Park-Bartlett Cove		National Park Service-Air Resources Division	03/10
	AK06	Gates of the Arctic NP - Bettles	NTN	US Bureau of Land Management	11/08
	AK98	Kodiak		State of Alaska Department of Environmental Conservatio	09/07
<b>Arizona</b>					
	AZ02	Sycamore Canyon		Arizona Department of Environmental Quality/EPA	02/06
<b>California</b>					
	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
<b>Colorado</b>					
	CO13	Fort Collins	AMoN	Colorado State University	06/12
	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
<b>Florida</b>					
	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
	FL34	Everglades Nutrient Removal Project		South Florida Water Management District	07/97
	FL96	Pensacola	AMNet	Atmospheric Research and Analysis, Inc	12/10
	FL97	Everglades - Western Broward County		South Florida Water Management District	11/06
<b>Georgia</b>					
	GA09	Okefenokee NWR	NTN	US Fish & Wildlife Service - Air Quality Branch Georgia Department of Natural Resources /Sapelo Island NERR	07/97
	GA33	Sapelo Island	NTN		09/07
	GA40	Yorkville	AMNet/AMoN	Atmospheric Research and Analysis, Inc	06/00
<b>Illinois</b>					
	IL11	Bondville	AIRMoN/NTN/ AMoN	Illinois State Water Survey/NADP	01/99
<b>Indiana</b>					
	IN34	Indiana Dunes NL	NTN	National Park Service - Air Resources Division	10/00
<b>Kansas</b>					
	KS03	Reserve	AMoN	Kansas Department of Health and Environment	01/08
	KS04	West Mineral		Kansas Department of Health and Environment	10/08
	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
	KS99	Cimarron National Grassland		Kansas Department of Health and Environment	12/08

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Kentucky</b>				
KY10	Mammoth Cave NP-Houchin Meadow	NTN	National Park Service - Air Resources Division	08/02
<b>Maine</b>				
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	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
<b>Maryland</b>				
MD00	Smithsonian Environmental Res Ctr		MD DNR/Smithsonian Environmental Research Center	12/06
MD08	Piney Reservoir	NTN /AMNet/ AMoN	MD DNR/University of Maryland-Appalachian Lab	06/04
MD99	Beltsville	NTN /AMNet/ AMoN	Maryland Department of Natural Resources	06/04
<b>Massachusetts</b>				
MA01	North Atlantic Coastal Lab	NTN	NPS - Cape Cod National Seashore	07/03
<b>Michigan</b>				
MI48	Seney NWR - Headquarters	NTN	US Fish & Wildlife Service-Air Quality Branch	11/03

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Minnesota</b>				
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
<b>Mississippi</b>				
MS12	Grand Bay NERR	NTN /AMNet	Mississippi Department of Environmental Quality	03/10
MS22	Oak Grove		Atmospheric Research and Analysis, Inc	06/00
<b>Missouri</b>				
MO03	Ashland Wildlife Area	NTN	Missouri Department of Natural Resources /EPA	07/10
MO46	Mingo NWR		Missouri Department of Natural Resources /EPA	03/02
<b>Montana</b>				
MT05	Glacier NP - Fire Weather Station	NTN	National Park Service - Air Resources Division	10/03
MT95	Badger Peak		Northern Cheyenne Tribe	11/10
<b>Nebraska</b>				
NE15	Mead	NTN	Nebraska Department of Environmental Quality	06/07
NE25	Winnebago		Winnebago Tribe of Nebraska	11/09

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Nevada</b>					
	NV02	Lesperance Ranch		Nevada Dept of Conservation & Natural Resources/Frontier Global, Inc	01/03
	NV99	Gibb's Ranch		Nevada Dept of Conservation & Natural Resources/Frontier Global, Inc	02/03
<b>New Jersey</b>					
	NJ30	New Brunswick	AMNet	US Geological Survey	01/06
<b>New Mexico</b>					
	NM98	Navajo Lake	AMoN	New Mexico Environment Department-Air Quality Bureau	04/09
<b>New York</b>					
	NY06	Bronx	AMNet	New York Department of Environmental Conservation	01/08
	NY20	Huntington Wildlife	NTN/AMNet/ AMoN	Syracuse University /EPA	12/99
	NY43	Rochester		NYSERDA	01/08
	NY68	Biscuit Brook	NTN	US Geological Survey	03/04
<b>North Carolina</b>					
	NC08	Waccamaw State Park		North Carolina Dept of Environment & Natural Resources	02/96
	NC42	Pettigrew State Park		North Carolina Dept of Environment & Natural Resources	02/96

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State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Oklahoma</b>					
	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
	OK22	Miami		Peoria Tribe of Indians of Oklahoma	03/12
	OK31	Copan		Oklahoma Department of Environmental Quality	10/06
	OK99	Stilwell	AMNet/AMoN	Cherokee Nation/EPA	04/03
<b>Pennsylvania</b>					
	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
	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
	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

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>South Carolina</b>				
SC03	Savannah River	NTN	Savannah River Nuclear Company	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
<b>South Dakota</b>				
SD18	Eagle Butte		Cheyenne River Sioux Tribe/EPA	03/07
<b>Tennessee</b>				
TN11	Great Smoky Mountains NP-Elkmont	NTN	National Park Service - Air Resources Division	01/02
<b>Texas</b>				
TX21	Longview	NTN	Texas Commission on Environmental Quality	03/96
<b>Utah</b>				
UT97	Salt Lake City	AMNet/AMoN	Utah Department of Environmental Quality	05/07
<b>Vermont</b>				
VT99	Underhill	AIRMoN/NTN/ AMNet	Univ of VT-Rubinstein School of Env & Nat Res/NEIWPC	07/04
<b>Virginia</b>				
VA28	Shenandoah NP-Big Meadows	NTN	National Park Service - Air Resources Division	10/02
<b>Washington</b>				
WA03	Makah National Fish Hatchery		Frontier Global Sciences	03/07
WA18	Seattle - NOAA		Illinois State Water Survey & Frontier Global Sciences Inc	03/96

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>West Virginia</b>				
WV99	Canaan Valley Institute	AIRMoN/ AMNet	NOAA - Air Resources Lab	06/07
<b>Wisconsin</b>				
WI08	Brule River		Wisconsin Department of Natural Resources	03/96
WI09	Popple River	NTN	Wisconsin Department of Natural Resources	03/96
WI10	Potawatomi	NTN	Forest County Potawatomi Community/EPA	06/05
WI22	Milwaukee		Wisconsin Department of Natural Resources	10/02
WI31	Devils Lake		Wisconsin Department of Natural Resources	01/01
WI36	Trout Lake	NTN	Wisconsin Department of Natural Resources	03/96
WI99	Lake Geneva	NTN	Wisconsin Department of Natural Resources	01/97
<b>Wyoming</b>				
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
<b>CANADA</b>					
<b>Alberta</b>					
	AB13	Henry Kroeger		ATCO Power	09/04
	AB14	Genesee		Jacques Whitford Stantec Axy's Ltd.	07/06
<b>British Columbia</b>					
	BC16	Saturna Island		Environment Canada	09/09
<b>Nova Scotia</b>					
	NS01	Kejimikujik NP	AMNet	Environment Canada	07/96
<b>Ontario</b>					
	ON07	Egbert		Environment Canada	03/00
<b>Quebec</b>					
	PQ17	Chapais		Environment Canada	11/09
<b>Saskatchewan</b>					
	SK12	Bratt's Lake BSRN		Environment Canada	05/01

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# AMNet Map and Site Listings

### National Atmospheric Deposition Program Atmospheric Mercury Network



## National Atmospheric Deposition Program/Atmospheric Mercury Network Sites

July 31, 2012

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>Alabama</b>				
AL19	Birmingham	MDN	Atmospheric Research & Analysis, Inc.	12/10
<b>California</b>				
CA48	Elkhorn Slough		USEnvironmental Protection Agency-CAMD	01/10
<b>Florida</b>				
FL96	Panacola	MDN	Atmospheric Research & Analysis, Inc.	12/10
<b>Georgia</b>				
GA40	Yorkville	MDN/AMoN	Atmospheric Research & Analysis, Inc.	12/10
<b>Hawaii</b>				
HI00	Mauna Loa		National Oceanic & Atmospheric Administration	01/12
<b>Maryland</b>				
MD08	Piney Reservoir	MDN/NTN/AMoN	State of Maryland	01/08
MD98	Beltsville II		NOAA USEnvironmental Protection Agency-CAMD	01/07
MD99	Beltsville	MDN/NTN/AMoN	NOAA USEnvironmental Protection Agency-CAMD	11/06
<b>Mississippi</b>				
MS12	Grand Bay NERR	MDN/NTN	National Oceanic & Atmospheric Administration	09/06
MS99	Grand Bay NERR II		National Oceanic & Atmospheric Administration	10/07

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
<b>New Jersey</b>				
NJ30	New Brunswick	MDN	State of New Jersey	07/02
NJ54	Elizabeth Lab		State of New Jersey	01/04
<b>New York</b>				
NY06	New York City	MDN	State of New York	08/08
NY20	Huntington Wildlife Forest	MDN/NTN/AMoN	US Environmental Protection Agency-CAMD	11/07
NY95	Rochester B		State of New York/NYSERDA	09/08
<b>Oklahoma</b>				
OK99	Stilwell	MDN/AMoN	Cherokee Nation	10/08
<b>Utah</b>				
UT97	Salt Lake City	MDN/AMoN	State of Utah	11/08
<b>Vermont</b>				
VT99	Underhill	AIRMoN/MDN/NTN	US Environmental Protection Agency-CAMD	01/08
<b>West Virginia</b>				
WV99	Canaan Valley Institute	MDN/AIRMoN	National Oceanic & Atmospheric Administration	01/07

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State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Canada	NS01	Kejimikujik NP	MDN	Environment Canada	01/09
Taiwan	TW01	Mt. Lunil		Taiwan EPA	01/12









The National Atmospheric Deposition Program 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. NAPAP continues under Title IX of the federal Clean Air Act Amendments of 1990.

In October 1992, the AIRMoN joined the NADP. AIRMoN sites collect samples daily when precipitation occurs. In January 1996, the NADP established the 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, AMNet joined the NADP as the fourth network. AMNet measures the concentration of atmospheric mercury. In October 2010, AMoN joined the NADP, measuring atmospheric ammonia concentrations using passive monitors.

SAES project NRSP-3 was renewed in 2009, 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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