NADP Scientific Symposium Agenda

NADP Annual Meeting and Scientific Symposium
San Diego, California
October 30–November 3, 2017

Monday, October 30, 2017		**Room Location**
9:00 a.m. – 12:00 p.m.	CLAD	Shell
10:00 a.m. – 12:00 p.m.	AMSC	Del Mar
12:30 p.m. – 4:30 p.m.	TDEP	Del Mar
3:00 p.m. – 5:00 p.m.	CLAD	Shell

Tuesday, October 31, 2017

Open All Day	Registration Desk	Mezzanine
8:30 a.m. – 10:00 a.m.	Joint Subcommittee Meeting	Bay E
10:00 a.m. – 10:15 a.m.	Break	Foyer
10:15 a.m. – 12:00 p.m.	Subcommittee Meetings	
	Network Operations	Bay E
	Ecological Response and Outreach	Del Mar
	Critical Loads	Shell
12:00 p.m. – 1:30 p.m.	Lunch on your own	
1:30 p.m. – 2:30 p.m.	Joint Subcommittee Meeting	Bay E
2:30 p.m. – 3:00 p.m.	Break	Foyer
3:00 p.m. – 6:00 p.m.	Executive Committee Meeting	Del Mar
6:00 p.m.	City Dep Ad-hoc Subcommittee	Shell

Wednesday, November 1, 2017		**Room Location**
Open All Day	Registration/Office	Mission Foyer
8:00 a.m. – 8:30 a.m.	**Welcome, Program Office Report** **Awards and Announcements** Tamara Blett: NADP Vice Chair, Symposium Chair National Park Service Donna Schwede: NADP Chair U.S. EPA	Mission A, B, C, D
8:30 a.m. – 9:15 a.m.	**Mapping the Future of NADP** **NADP Executive Committee**	
9:15 a.m. – 10:00 a.m.	**Annual State of the NADP Report** David Gay: NADP Program Coordinator	
10:00 a.m. – 10:30 a.m.	Break	Mission Foyer
Technical Session 1:	**Critical Loads: Acidification and Excess Nitrogen Thresholds** Session Chair: Mike Bell National Park Service	
10:30 a.m. – 10:50 a.m.	**Developing Critical Loads of Acidity for Stream Ecosystems in the Adirondack Region of New York State** Shuai Shao, Syracuse University	
10:50 a.m. – 11:10 a.m.	**Critical Load of Sulphur and Nitrogen for Terrestrial Ecosystems in Alberta, Canada: Sensitivity to Input Data** Yayne-abeba Aklilu, Government of Alberta	
11:10 a.m. – 11:30 a.m.	**Extreme nitrogen saturation of serpentine grasslands in Santa Clara County, California: A nexus for conservation action** Stuart Weiss, Creekside Center for Earth Observation	
11:30 a.m. – 11:50 a.m.	**Individual tree species' responses to concurrent nitrogen and sulfur deposition across the contiguous United States** Kevin Horn, Forest Resources and Environmental Conservation, Virginia Tech	
11:50 a.m. – 12:10 p.m.	**Critical loads of nitrogen deposition for trees and forest ecosystems across the continental U.S.** Linda Pardo, USDA Forest Service	

Wednesday, November 1, 2017 **Room Location**

Mission A, B, C, D

12:10 p.m. – 12:30 p.m. **Recent Advances in Critical Loads Research**
Christopher Clark, US EPA

12:30 p.m. – 2:00 p.m. Lunch on your own

Technical Session 2: **Air & Water Quality: Linkages and Synergies**
Session Chairs: Mark Nilles and Helen Amos
USGS and US EPA
Moderator: Rich Pouyat, USDA Forest Service

2:00 p.m. – 2:20 p.m. **Bridging the air-water quality information gap to improve nutrient management**
Helen Amos, AAAS Fellow hosted by US EPA

2:20 p.m. – 2:40 p.m. **CMAQ modeling in the nitrogen inventory study in the Nooksack-Abbotsford-Sumas Transboundary Region**
Donna Schwede, US EPA

2:40 p.m. – 3:00 p.m. **Episodic Acidification in the Adirondack Region of New York: Spatial Patterns and Evidence of Recovery**
Douglas Burns, U.S. Geological Survey

3:00 p.m. – 3:30 p.m. Break

Technical Session 3: **Air & Water Quality: Linkages and Synergies (cont.)**
Session Chairs: Mark Nilles and Helen Amos
USGS and US EPA
Moderator: Rich Pouyat, USDA Forest Service

3:30 p.m. – 3:50 p.m. **Changes in stream chemistry at high flow during 23 years of decreasing acid deposition in the Catskill Mountains of New York**
Michael McHale, U.S. Geological Survey

3:50 p.m. – 4:10 p.m**.** **Evaluating Potential Water Quality Impairments on National Forest Priority Watersheds Using Estimates of Atmospheric Deposition**
David Levinson, U.S. Forest Service

4:10 p.m. – 4:30 p.m**.** **Integration of atmospheric deposition and water quality monitoring in the El Yunque National Forest, Puerto Rico**
Anita K. Rose, USDA Forest Service

Wednesday, November 1, 2017 **Room Location**

4:30 p.m. – 5:30 p.m. Break

5:30 p.m. – 8:00 p.m. **Poster Session and Reception** William D. Evans

Thursday, November 2, 2017 **Room Location**

Open All Day Registration/Office Mission Foyer

Thursday, November 2, 2017 **Room Location**

Mission A, B, C, D

8:00 a.m. – 8:10 a.m. **Opening Remarks, Announcements, and Overview of Day 2**
Tamara Blett, NADP Vice Chair,
National Park Service

8:10 a.m. – 8:40 a.m. **Keynote Address**
Dr. Lynn Russell
Professor of Atmospheric Chemistry
Scripps Institution of Oceanography

Technical Session 4: **Deposition Modeling and Monitoring**
Session Chair: Anne Rea and Eric Prestbo
USDA Forest Service and Tekran

8:40 a.m. – 9:00 a.m. **Evaluation of wet atmospheric deposition along the coast of the Gulf of Mexico:- An international collaboration opportunity**
Rodolfo Sosa, Universidad Nacional Autonoma de Mexico

9:00 a.m. – 9:20 a.m. **Methylmercury and total mercury in marine stratus cloud and fog water: Sources, sinks, and lifetimes**
Peter Weiss-Penzias, University of California, Santa Cruz,

9:20 a.m. – 9:40 a.m. **Trends in NADP bromide wet deposition concentrations, 2001-2016**
Gregory Wetherbee, U.S. Geological Survey

9:40 a.m. – 10:00 a.m. **Total deposition by measurement-model fusion using ADAGIO**
Amanda Cole, Environment and Climate Change Canada

10:00 a.m. – 10:30 a.m. Break

Thursday, November 2, 2017	**Room Location**
	Mission A, B, C, D
Technical Session 5:	**Urban Air Quality and Deposition** Session Chair: Steven Decina Boston University
10:30 a.m. – 10:50 a.m.	**Quantifying urban nitrogen emission and deposition through optical sensing techniques** Kang Sun, Harvard-Smithsonian Center for Astrophysics
10:50 a.m. – 11:10 a.m.	**Using Moss to Detect Fine-Scaled Deposition of Heavy Metals in Urban Environments** Sarah Jovan, U.S. Forest Service Pacific Northwest Research Station
11:10 a.m. – 11:30 a.m.	**Elemental carbon deposition to urban tree canopies: Magnitudes and spatial patterns** Alexandra G. Ponette-González, Department of Geography and The Environment, University of North Texas
11:30 a.m. – 11:50 a.m.	**Characteristics and Ecological Impacts of Atmospheric Deposition in Urban and Urban-Affected Regions** Mark Fenn, USDA Forest Service, PSW Research Station
11:50 a.m. – 12:10 p.m.	**Assessing Sources and Fluxes of Reactive Nitrogen Deposition to Urban Landscapes Using Ion Exchange Resins** Rebecca Forgrave, University of Pittsburgh
12:10 p.m. – 12:30 p.m.	**Increasing ethanol consumption as a renewable fuel: How will vehicle ethanol emissions impact the urban atmosphere?** J. David Felix, Texas A&M University - Corpus Christi
12:30 p.m. – 2:00 p.m.	Lunch on your own
Technical Session 6:	**Nitrogen: Transport Deposition and Effects** Session Chair: Justin Valliere University of California Los Angeles
2:00 p.m. – 2:20 p.m.	**Ecosystem flip-flops in response to anthropogenic N deposition: The importance of long-term experiments** George Vourlitis, California State University

Thursday, November 2, 2017 **Room Location**

Mission A, B, C, D

2:20 p.m. – 2:40 p.m. **Organic nitrogen in aerosols at a forest site in southern Appalachia**
John Walker, US EPA

2:40 p.m. – 3:00 p.m. **Quantifying nitrogen deposition inputs and impacts on plant richness in a Mediterranean-type shrubland**
Justin Valliere, University of California Los Angeles

3:00 p.m. – 3:30 p.m. Break

Technical Session 7: **Nitrogen: Transport Deposition and Effects (cont.)**
Session Chair: Justin Valliere
University of California Los Angeles

3:30 p.m. – 3:50 p.m. **Atmospheric deposition evaluation as a tool to preserve urban natural green areas: Mexico City case**
María Alejandra Fonseca

3:50 p.m. – 4:10 p.m. **Spatial and temporal relationships of key nitrogen species between ambient and deposition regimes**
Richard Scheffe, US EPA

4:10 p.m. – 4:30 p.m. **Nutrient deposition in the headwaters of streams may impact nitrogen loading in Southern Californian estuaries**
Pamela Padgett, USDA Forest Service

4:30 p.m. – 4:50 p.m. **Contributions of organic nitrogen to the gas phase and speciation of amines in ambient samples**
Katherine Benedict, Colorado State University

Friday, November 3, 2017 **Room Location**

Open A.M. Session Registration/Office Mission Foyer

Friday, November 3, 2017	**Room Location**
	Mission A, B, C, D

8:00 a.m. – 8:10 a.m.	**Opening Remarks, Announcements, and Overview of Day 3** Tamara Blett, NADP Vice Chair National Park Service
Technical Session 8:	**Ammonia Emissions, Trends, Deposition** Session Chair: Katie Benedict Colorado State University
8:10 a.m. – 8:30 a.m.	**Investigation of hourly concentration ratios of ammonia gas and particulate ammonium at CASTNet site in Beltsville, MD** Greg Beachley, US EPA
8:30 a.m. – 8:50 a.m.	**Urban and On-Road Emissions: Underappreciated Sources of Atmospheric Ammonia** Mark Fenn, USDA Forest Service, PSW Research Station
8:50 a.m. – 9:10 a.m.	**“Fingerprinting” Vehicle-Derived Ammonia Utilizing Nitrogen Stable Isotopes** Wendell Walters, Brown University
9:10 a.m.	Adjourn
8:30 a.m. – 6:00 p.m.	Optional Field Trips – Marine ecosystem field trip by kayak to LaJolla Sea Caves (morning trip 8:30 departure from hotel and afternoon trip 12:30 p.m. departure from hotel)

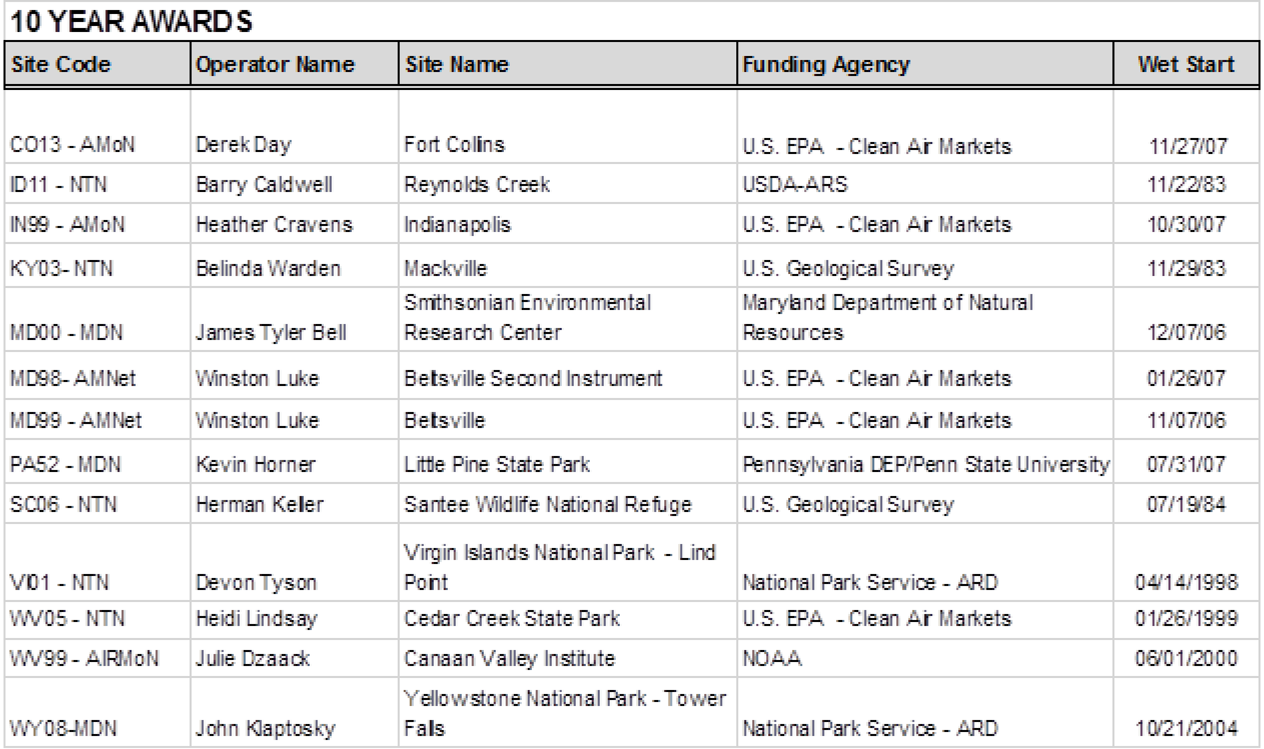
2017 NADP SITE OPERATOR AWARDS

5 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
CA75 - MDN	Erik Meyer	Sequoia National Park- Giant Forest	National Park Service - ARD	07/22/03
CA75 - NTN	Erik Meyer	Sequoia National Park- Giant Forest	National Park Service - ARD	07/08/80
CA83 - AMoN	Erik Meyer	Sequoia National Forest - Ash Mountain	National Park Service - ARD	03/22/11
CA96 - NTN	Elizabeth Hale	Lassen Volcanic National Park - Manzanita Lake	National Park Service - ARD	06/13/00
IN20 - NTN	Karey Davis	Roush Lake	U.S. Geological Survey	08/22/83
KY99 - NTN	Clark Hendrix	Mulberry Flat	Murray State University	12/27/94
MD08 - AMoN	Mark Castro	Piney Reservior	Maryland Department of Natural Resources	08/03/10
MN23 - MDN	Meg Nygren	Camp Ripley	Minnesota Pollution Control Agency	07/02/96
MN23 - NTN	Meg Nygren	Camp Ripley	U.S. Geological Survey	10/18/83
MT98 - NTN	Julia Dafoe	Havre - Northern Agricultural Research Center	U.S. Geological Survey	07/30/85
NC30 - AMoN	Scott Moore	Duke Forest	U.S. EPA - Clean Air Markets	06/24/08
NH02 - AMoN	Brenda Minicucci	Hubbard Brook	U.S. EPA - Clean Air Markets	06/05/12
NH02 - NTN	Amey Bailey	Hubbard Brook	U.S. Forest Service	07/25/78
NS01 - AMNet	Robert Keenan	Kejimkujik National Park	Environment Canada	01/26/09
NY20 -AMoN	Charlotte Demers	Huntington Wildlife	U.S. EPA - Clean Air Markets	06/05/12

5 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
NY52 - NTN	Steven Skubis	Bennett Bridge	U.S. EPA - Clean Air Markets	06/10/80
NY98 - NTN	Paul Casson	Whiteface Mountain	U.S. Geological Survey	07/03/84
PA21 - NTN	Kevin Horner	Goddard State Park	Pennsylvania DEP/Penn State University	07/26/11
PA98 - NTN	Kevin Horner	Frances Slocum State Park	Pennsylvania DEP/Penn State University	07/26/11
SC03 - MDN	Richard Walker	Savannah River	Savannah River Nuclear Solutions	01/29/01
SK21 - NTN	Gloria Stang	Hudson Bay	Saskatchewan Ministry of Environment	04/30/12
UT01 - AMoN	Randy Martin	Logan	Utah Department of Environmental Quality	11/08/11
UT01 - NTN	Randy Martin	Logan	U.S. Geological Survey	12/06/83
WV18 - AMoN	Chris Cassidy	Parsons	U.S. EPA - Clean Air Markets	06/07/11
WV18 -NTN	Chris Cassidy	Parsons	U.S. Forest Service	07/05/78
WY95 - AMoN	John Korfmacher	Brooklyn Lake	U.S. EPA - Clean Air Markets	06/19/12
WY99 - NTN	Eric Schnell	Newcastle	U.S. Bureau of Land Management	08/11/81



10 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
CO13 - AMoN	Derek Day	Fort Collins	U.S. EPA - Clean Air Markets	11/27/07
ID11 - NTN	Barry Caldwell	Reynolds Creek	USDA-ARS	11/22/83
IN99 - AMoN	Heather Cravens	Indianapolis	U.S. EPA - Clean Air Markets	10/30/07
KY03- NTN	Belinda Warden	Mackville	U.S. Geological Survey	11/29/83
MD00 - MDN	James Tyler Bell	Smithsonian Environmental Research Center	Maryland Department of Natural Resources	12/07/06
MD98- AMNet	Winston Luke	Beltsville Second Instrument	U.S. EPA - Clean Air Markets	01/26/07
MD99 - AMNet	Winston Luke	Beltsville	U.S. EPA - Clean Air Markets	11/07/06
PA52 - MDN	Kevin Horner	Little Pine State Park	Pennsylvania DEP/Penn State University	07/31/07
SC06 - NTN	Herman Keller	Santee Wildlife National Refuge	U.S. Geological Survey	07/19/84
VI01 - NTN	Devon Tyson	Virgin Islands National Park - Lind Point	National Park Service - ARD	04/14/1998
WV05 - NTN	Heidi Lindsay	Cedar Creek State Park	U.S. EPA - Clean Air Markets	01/26/1999
WV99 - AIRMoN	Julie Dzaack	Canaan Valley Institute	NOAA	06/01/2000
WY08-MDN	John Klaptosky	Yellowstone National Park - Tower Falls	National Park Service - ARD	10/21/2004

15 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
KY10 - MDN	Johnathan Jernigan	Mammoth Cave National Park - Houchin Meadow	National Park Service - ARD	08/27/2002
KY10 - NTN	Johnathan Jernigan	Mammoth Cave National Park - Houchin Meadow	National Park Service - ARD	08/27/2002
ME08 - NTN	Kurt Johnson	Gilead	U.S. Geological Survey	09/28/1999
MT97 - NTN	Tanya Niedhardt	Lost Trail Pass	USDA Forest Service	09/25/1990
NY01 - NTN	Wes Bentz	Alfred	U.S. Geological Survey	08/17/2004
PA00 - MDN	Sharon Scamack	Arendtsville	Pennsylvania DEP/Penn State University	11/14/2000
SD04 - NTN	Marc Ohms	Wind Cave National Park - Elk Mountain	National Park Service - ARD	11/05/2002
VA99 - NTN	Ken Hickman	Natural Bridge Station	USDA Forest Service	07/02/2002
WI36 - NTN	Therese Hubacher	Trout Lake	Wisconsin Department of Natural Resources	01/22/1980
WI36 - MDN	Therese Hubacher	Trout Lake	Wisconsin Department of Natural Resources	03/05/1996

20 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
GA09 - MDN	Ronald Phernetton	Okefenokee National Wildlife Refuge	U.S. Fish and Wildlife Service - Air Quality Bureau	07/29/1997
MN08 - NTN	Mary Jo Flack	Hovland	Minnesota Pollution Control Agency	12/31/1996
MT00 - NTN	Wayne Not Afraid	Little Bighorn Battlefield National Monummet	U.S. Geological Survey	07/13/1984
VT99 - NTN	Miriam Pendleton	Underhill	U.S. Geological Survey	06/12/1984

25 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
AK03-NTN	Andrea Blakesley	Denali National Park - Mt. McKinley	National Park Service - ARD	06/07/80
IL11 -AIRMoN	Michael Snider	Bondville	Illinois State Water Survey	10/01/1992
MT96 - NTN	Linda Conner Weeks	Poplar River	Fort Peck Tribes	12/21/1999
NY67 - AIRMoN	Tom Butler	Ithaca	NOAA-ARL	09/30/1992

30 YEAR AWARDS

Site Code	Operator Name	Site Name	Funding Agency	Wet Start
FL41 - NTN	April Ammeson	Verna Well Field	U.S. Geological Survey	08/25/1983
KS31 - NTN	Rosemary Ramundo	Konza Prairie	Kansas State University (SAES)	08/17/1982
KY22 - NTN	Robert Watts	Lilley Cornett Woods	U.S. Geological Survey	09/06/1983

KEYNOTE SPEAKER

DR. LYNN RUSSELL,
PROFESSOR OF CLIMATE, ATMOSPHERIC SCIENCE AND PHYSICAL OCEANOGRAPHY – SCRIPPS INSTITUTE OF OCEANOGRAPHY, UC SAN DIEGO

Biography

Professor of Atmospheric Chemistry

Lynn M. Russell is Professor of Atmospheric Chemistry at Scripps Institution of Oceanography on the faculty of University of California at San Diego, where she has led the Climate Sciences Curricular Group since 2009. Her research is in the area of aerosol particle chemistry, including the behavior of particles from both biogenic and combustion processes. Her research group pursues both modeling and measurement studies of atmospheric aerosols, using the combination of these approaches to advance our understanding of fundamental processes that affect atmospheric aerosols. She completed her undergraduate work at Stanford University, and she received her Ph.D. in Chemical Engineering from the California Institute of Technology for her studies of marine aerosols. Her postdoctoral work as part of the National Center for Atmospheric Research Advanced Studies Program investigated aerosol and trace gas flux and entrainment in the marine boundary layer. She served on the faculty of Princeton University in the Department of Chemical Engineering before accepting her current position at Scripps in 2003. She has been honored with young investigator awards from ONR, NASA, Dreyfus Foundation, NSF, and the James S. McDonnell Foundation, and she received the Kenneth T. Whitby Award from AAAR (2003) for her contributions on atmospheric aerosol processes and the Princeton Rheinstein Award for excellence in teaching and scholarship (1998).

TECHNICAL SESSION 1:

CRITICAL LOADS: ACIDIFICATION AND EXCESS NITROGEN THRESHOLDS

Session Chair: Mike Bell,
National Park Service

Developing Critical Loads of Acidity for Stream Ecosystems in the Adirondack Region of New York State

Shuai Shao[1], Charles T. Driscoll[2], Douglas A. Burns[3], Gregory B. Lawrence[4] and Timothy J. Sullivan[5]

The Adirondack region of New York has high inputs of acidic deposition and many acidic streams. The PnET-BGC is an integrated biogeochemical model formulated to simulate the response of soil and surface waters in northern forest ecosystems to changes in atmospheric deposition. In this is study, the model was applied to twenty-one streams in the Adirondacks to simulate the effects of past and future (1000-2200) changes in atmospheric sulfur (S) and nitrogen (N) deposition on stream water chemistry. The model was calibrated using observed stream water and soil chemistry data. The results indicated model simulated stream water chemistry generally agreed with the measured data at all sites. Model hindcasts indicated that stream water in the Adirondack are inherently sensitive to acidic deposition. The average of model simulated stream ANC is 175 μeq/L (range 48 to 335 μeq/L) before anthropogenic disturbances are applied to the model (1850) and it decreased in response to historical acidic deposition to 59 μeq/L (−37 to 242 μeq/L) in 2015. The model was run under a range of future scenarios from 2016 to 2200 of changes in sulfate, nitrate, and combination of sulfate and nitrate deposition to evaluate how the stream water chemistry might respond to emission control strategies. Future model projections suggested that decreases in sulfate deposition is more effective in increases in stream ANC compared with equivalent decreases in nitrate deposition; nevertheless, the simultaneous controls on nitrate and sulfate deposition are more effective way to restore stream ANC than individual control of nitrate or sulfate deposition. However, only ten of the twenty-one sites will restore the stream ANC to the preindustrial level under the most aggressive deposition reduction scenarios. The model results were used to determine the critical loads of acidity (CLs, the level of atmospheric deposition above which the harmful ecosystem effects occur) for all twenty-one sites.

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Critical Load of Sulphur and Nitrogen for Terrestrial Ecosystems in Alberta, Canada: Sensitivity to Input Data

Yayne-abeba Aklilu[1], Laura Blair[2], Gordon Dinwoodie[3], Julian Aherne[4], Naomi Tam[5] and Sunny Cho[6]

The steady state mass balance model (SSMB) was used to calculate the critical loads of acidity: the maximum critical loads for sulphur ($CL_{max}(S)$) and nitrogen ($CL_{max}(N)$) deposition and the minimum critical load for nitrogen deposition ($CL_{min}(N)$). These critical loads were calculated for terrestrial ecosystems in the province of Alberta. While SSMB is relatively simple to use, the challenge in using this model lies in estimating the required input especially for large study area such as a province (661,848 km^2). Base cation weathering and appropriate application of chemical criteria are two such critical inputs. For this work, the soil texture approximation method and soils information from a national soil database was used to determine base cation weathering. The chemical criteria, base cation to aluminum ratio, used to determine acid neutralizing capacity leaching was applied by land use. Higher $CL_{max}(S)$ and $CL_{max}(N)$ (> 600 eq $ha^{-1}yr^{-1}$) resulted for areas of the province with deeper soil and higher clay content providing the conditions which can result in higher base cation weathering. $CL_{max}(S)$ and $CL_{max}(N)$ less than 200 eq $ha^{-1}yr^{-1}$ were determined for areas with sandy acidic soils as well as soils with higher organic content. The distribution of $CL_{min}(N)$ reflects biomass nitrogen content and removal of harvested biomass. For the most part $CL_{min}(N)$was less than 100 eq $ha^{-1}yr^{-1}$ with some areas having a $CL_{min}(N)$ less than 50 eq $ha^{-1}yr^{-1}$. Areas with $CL_{min}(N)$ greater than 50 eq $ha^{-1}yr^{-1}$ contain managed forests which have notable nitrogen removal rates from biomass harvest and removal. Exceedance of critical loads can indicate areas of potential ecosystem impact and areas that need focused deposition monitoring. Exceedances and sensitivity of these exceedances are explored using modelled sulphur and nitrogen deposition and calculated critical loads of acidity. The findings are used to better inform the precipitation monitoring network for the province.

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Extreme Nitrogen Saturation of Serpentine Grasslands in Santa Clara County, California: A Nexus for Conservation Action

Stuart Weiss[1] and Meredith Hastings[2]

Serpentine grasslands are nutrient-poor, low biomass ecosystems that harbor high native biodiversity including many listed species such as the Bay checkerspot butterfly. Research since the 1990s has documented the threat of atmospheric nitrogen deposition from upwind Silicon Valley that allows non-native annual grasses to overrun the dazzling displays of low-statured wildflowers, and that the grass invasions are controlled by managed cattle grazing. The estimated critical load for serpentine grasslands is 6 kg-N ha^{-1} $year^{-1}$. Since 2015, in the high deposition zone (10-20 kg-N ha^{-1} $year^{-1}$), spring water nitrate up to 25 ppm (as NO_3^-) were measured in baseflow, levels higher than any reported for non-agricultural sites in California. Nitrate levels in samples from low deposition areas were 1-5 ppm. Isotopic analyses including $\Delta^{17}O$ show that 50-60% of the nitrate in spring and well water is unprocessed atmospheric nitrate. Passive samplers, CMAQ models, N-cycling measurements, and emissions inventories/projections are used to interpret the findings. High levels of nitric acid in summer and low ecosystem capacity for N-retention in the fall growing season allow for flushing of accumulated dry NO_3 deposition into the fractured bedrock, and eventually into the springs. Increased N-deposition from highway improvements and development was a major regulatory nexus for the Santa Clara Valley Habitat Plan, a Habitat Conservation Plan/Natural Communities Conservation Plan (HCP/NCCP). A novel nitrogen fee based on car trips generated is one of the funding mechanisms, driving a need for cost-effective and robust monitoring of N-deposition trends over the 50-year plan and beyond. A set of sentinel springs for long-term monitoring will be identified and sampled on an interval commensurate with shallow groundwater residence times.

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Individual Tree Species' Responses to Concurrent Nitrogen and Sulfur Deposition across the Contiguous United States

Kevin Horn[1], R. Quinn Thomas[2], Linda H. Pardo[3], Christopher M. Clark[4], Mark E. Fenn[5], Gregory B. Lawrence[6], Steven S. Perakis[7], Erica A.H. Smithwick[8], Douglas Baldwin[9], Sabine Braun[10] and et al.[11]

Atmospheric deposition of nitrogen (N) and sulfur (S) concurrently impact temperate forests through similar and diverse mechanisms. Both N and S compounds contribute to soil acidification; however, N deposition also affects individual tree physiology and stand competition through eutrophication. Tree responses to S and N deposition can be difficult to separate, especially since N and S deposition often originate from common sources. Additionally, tree responses to deposition are controlled by individual species physiologies and the influence of local soil and climatic factors. Understanding the impacts of S and N deposition, both separate and concerted, on demographics of tree species will help identify how forests and forest resources are changing, and facilitate setting response thresholds for N and S deposition.

Here we examine tree growth and survival rates against modeled N and S deposition and climate at the species level for the contiguous United States. Of the 94 species examined, growth and/or survival of 74 and 66 tree species were associated with S and/or N deposition, respectively. Only 5 species showed no relationship with S or N deposition in either growth or survival. Of the 94 tree species, 30 tree species increased in growth with N deposition, 6 decreased, and 19 increased then decreased while 39 showed no relationship with N deposition. For survival, 5 increased, 6 decreased, and 26 increased then decreased while 57 did not change across N deposition gradients. Only non-positive responses to S deposition were allowed in the models, for which 41 and 51 of the 94 species showed negative growth and survival responses, respectively. When N deposition was considered without S deposition in the models, growth and survival responses associated with N deposition decreased from an average rate of 17 Δkg C/Δkg N to 9.9 Δkg C/Δkg N and -0.065 $\Delta\%P(s)/\Delta$kg N ha^{-1}yr^{-1} to -0.441 $\Delta\%P(s)/\Delta$kg N ha^{-1}yr^{-1}. Surprisingly, the presence of S deposition in the models affected observed N deposition responses regardless of the correlation between N and S inputs. Nonetheless, forest sensitivities to N and S deposition seemed to be associated with species-specific mechanisms as co-occurring species often demonstrated contrasting responses. These relationships of tree species dynamics across highly variable N and S deposition gradients provide estimates for N and S deposition impacts on forests in the U.S. and identify quantifiable thresholds for species responses to N and S deposition.

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Critical Loads of Nitrogen Deposition for Trees and Forest Ecosystems across the Continental U.S.

Linda Pardo[1], Kevin J. Horn[2], Christopher M. Clark[3] and R. Quinn Thomas[4]

Critical loads of nitrogen deposition and exceedance of critical loads are being used increasingly by resource managers and policy makers to assess the risk of detrimental effects to forests. A recent analysis has allowed us to calculate critical loads for tree growth and survival in a systematic way for over fifty species across the continental US.

We used United States Forest Service Forest Inventory and Analysis (FIA) data with modeled S and N deposition rates and climate data to identify species-specific responses of trees associated with S and N deposition across the conterminous United States. Growth and survival estimates were made from repeated measurements of more than 1.1 million individual trees measured between 2000 and 2016.

We used these data to set critical loads for growth (for 32 species) and survival (for 54 species) for individual tree species and for level 3 ecoregions across the continental US. Using FIA expansion factors we were able to assess the extent of forest area at risk from nitrogen deposition. These species-specific responses will allow resource managers to understand the likely impacts from atmospheric nitrogen deposition and to manager their forests accordingly. The critical loads and exceedance maps will allow policy makers to assess the likely impacts of current and future deposition scenarios.

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Recent Advances in Critical Loads Research

Christopher Clark[1], Kevin Horn[2], Linda Pardo[3], Robert Sabo[4], Jen Phelan[5], Jason Lynch[6] and Quinn Thomas[7]

Nitrogen and sulfur deposition have declined in the eastern U.S. since the 1980s and 1990s following the 1990 Amendments to the Clean Air Act, yet they remain significantly elevated above thresholds where sensitive ecological end points are affected. Here we summarize several projects on assessing ecosystem sensitivity to N and S deposition, and the ecosystem services affected. One focus of the talk is on forest health and biodiversity, and here we use recently available critical loads for 94 tree species to examine how individual tree species are affected across the conterminous U.S. We also explore methods for synthesizing this information to inform development of air quality policies under the secondary standards of the NAAQS. The views expressed here are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

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TECHNICAL SESSION 2:
AIR & WATER QUALITY: LINKAGES AND SYNERGIES

Session Chairs: Mark Nilles and Helen Amos,
USGS and US EPA
Session Moderator: Rich Pouyat, USDA Forest Service

Bridging the Air-Water Quality Information Gap to Improve Nutrient Management

Helen Amos[1], Chelcy Miniat[2], Lori A. Sprague[3], David Gay[4], Mark A. Nilles[5], Anne W. Rea[6], Richard V. Pouyat[7], Denice M. Shaw[8], Jerad Bales[9], Jeff Deacon[10], Jana E. Compton[11], Doug Burns[12], Jason A. Lynch[13], LaToya Myles[14], Pamela H. Templer[15], John T. Walker[16] and Dave Whitall[17]

Nutrient (nitrogen and phosphorus) enrichment in fresh and coastal waters is one of today's most pervasive, expensive, and challenging water quality issues in the US. Continued inputs of excess nitrogen (N) and phosphorus (P) have created chronic drinking water contamination, harmful algal blooms, and persistent hypoxic zones in some aquatic systems. Atmospheric deposition can be a significant non-point source of N and P over large regions of the continental U.S. - yet there is a shortage of coordinated information about how air quality impacts aquatic nutrient enrichment. WADeIn (Water Quality & Atmospheric Deposition Integration) is an interagency, multi-organization collaboration that aims to fill this gap and improve the coordination and integration of atmospheric deposition and surface water quality monitoring to better understand the sources, transport, and impacts of excess N and P. We present a call for better integration of atmospheric deposition and water quality monitoring for N and P at a national scale that leverages existing infrastructure and expertise with the long-term objective to develop an integrated air/water monitoring consortium. We examine several issues driving the need for enhanced integrated monitoring, including: coastal eutrophication, urban hotspots of deposition, shift from oxidized to reduced N deposition, land-use change and land management, and disappearance of pristine lakes. We offer specific next steps to move the U.S. towards a 21st-century integrated air/water monitoring consortium for improved management of ecosystems.

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CMAQ Modeling in the Nitrogen Inventory Study in the Nooksack-Abbotsford-Sumas Transboundary Region

Donna Schwede[1], Ellen Cooter[2], Jiajia Lin[3], Jana Compton[4] and Jill Baron[5]

Optimizing nitrogen (N) use for food production while minimizing the release of N and co-pollutants to the environment is an important challenge. The Nooksack-Abbotsford-Sumas Transboundary (NAS) Region, spanning a portion of the western interface of British Columbia, Washington State, the Lummi Nation and Nooksack Tribal lands, supports agriculture, estuarine fisheries, diverse wildlife, and vibrant urban areas. Excess N has contributed to surface and ground water pollution, shellfish closure, and impaired air quality (such as haze or smog) in some areas in the NAS Transboundary region. To reduce the release of N to the environment, collaborative approaches that engage all stakeholders and appropriate institutions are needed to integrate science, outreach and management efforts. The goal of the NAS Transboundary N inventory study is to quantify the sources and fate of N, including inputs and transfers within the watershed. We are synthesizing publicly available data on N sources including atmospheric deposition, sewage and septic inputs, fertilizer and manure applications, marine-derived N from salmon migrations, natural N-fixing vegetation, and more.

CMAQv5.2 is used to estimate daily total nitrogen deposition as well as other air quality indicators in the target year (2014) at a 4-km grid resolution. An existing 12-km CMAQ model of Western US is employed to provide boundary conditions for the new model. The model domain is centered on the NAS Transboundary region, and includes nearly all of Washington State and the Fraser Valley in Canada. Bi-directional CMAQ ammonia flux will be presented from simulations that couple the USDA EPIC model which provides estimates of agricultural fertilizer application form, timing and amount based on the NLCD2011 land use classification and USDA regional cropping and agricultural management patterns, with the CMAQ model.
The information on cross-boundary N inputs to the landscape will be coupled with stream and groundwater monitoring data and existing knowledge to estimate the N residual in the watershed and N transport out of the watershed. Results will inform N management in the search for the environmentally and economically viable and effective solutions. The NAS Transboundary Region study is one of seven international demonstration projects contributing knowledge of regional N budgets and collaborative approaches toward N management as part of the International Nitrogen Management System (INMS).

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Episodic Acidification in the Adirondack Region of New York: Spatial Patterns and Evidence of Recovery

Douglas Burns[1], Gregory Lawrence[2], Timothy Sullivan[3], Charles Driscoll[4], Shuai Shao[5] and Todd McDonnell[6]

Episodic acidification occurs when the pH and ANC of surface waters temporarily decrease during rain events and snowmelt. The principal drivers of episodic acidification are increases in sulfuric acid, nitric acid, organic acids, and dilution of base cations. In regions where surface waters are sensitive to acid deposition, episodic acidification may result in several days to weeks when ANC values may approach or decline below 0 µeq/L, a threshold below which increases in monomeric aluminum concentrations become evident, which may result in deleterious effects to sensitive aquatic biota. The Adirondack Mountains of New York is a region with abundant streams and lakes, many of which are highly sensitive to the effects of acid deposition. Long-term monitoring data indicate that pH and ANC in regional surface waters are increasing in response to decreases in the acidity of atmospheric deposition that result from decreasing SO_2 and NO_x emissions as the Clean Air Act and its ancillary rules and amendments have been implemented. Most surface-water monitoring focuses on low-flow and broad seasonal patterns, and less is known about how episodic acidification has responded to emissions decreases. We are exploring spatial and temporal patterns in episodic acidification through analysis of stream chemistry from surveys that target varying flow conditions as well as data from a few long-term intensively sampled stream monitoring sites. Each stream sample is assigned a flow percentile value based on a resident or nearby gage, and a statistical relation between ANC values and flow percentile is developed. The magnitude of episodic decreases in ANC increases as low-flow ANC increases, a pattern that likely results from an increasing influence of dilution, especially evident when low-flow ANC values exceed 100 µeq/L. Chronically acidic streams with low-flow ANC near 0 µeq/L show little episodic acidification, whereas streams with low-flow ANC values of about 50 µeq/L generally show ANC decreases to less than 0 µeq/L at high flow. Preliminary analysis of a 24-yr data set (1991-2014) at Buck Creek near Inlet, NY indicates that high-flow ANC has recovered twice as much as low-flow ANC, and values generally no longer decline below 0 µeq/L at the highest flows, which typically occur during spring snowmelt. Further analyses will explore how the drivers of episodic acidification vary across the region with low-flow ANC and whether clear trends are evident in the influence of these drivers over the past few decades.

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TECHNICAL SESSION 3:
AIR & WATER QUALITY: LINKAGES AND SYNERGIES (CONTINUED)

Session Chairs: Mark Nilles and Helen Amos,
USGS and US EPA
Session Moderator: Rich Pouyat, USDA Forest
Service

Changes in Stream Chemistry at High Flow during 23 Years of Decreasing Acid Deposition in the Catskill Mountains of New York

Michael McHale[1], Douglas Burns[2], Jason Siemion[3] and Michael Antidormi[4]

The Catskill Mountains of New York is a region with demonstrated sensitivity to acid rain. The headwaters of the Neversink River basin are the most sensitive waters in the region with both chronically and episodically acidic streams. High-flow events (storms and snowmelt) cause sharp reductions in acid neutralizing capacity (ANC) and increases in nitrate (NO_3^-) and inorganic monomeric aluminum (Al_{im}). Even as streams recover from chronic acidification because of reductions in acidic deposition, episodic acidification may continue to cause sharp declines in ANC and increases in NO_3^-NO3- and Al_{im} that can have deleterious effects on stream ecosystems. We examined changes in stream chemistry throughout a 23 year period of decreasing acid deposition across all flow conditions, with particular emphasis on examining changes during high flow. Our results indicate that both chronically and episodically acidic streams are improving at similar rates and that trends were similar between high flow and all flow conditions. Initially we focused on spring snowmelt; we computed Mann-Kendall trends for stream chemistry during April of each year because April is the month during which peak spring streamflow typically occurs in this region. We found that ANC and sulfate (SO_4^{2-}) trends were of similar magnitude and direction between April-only and annual seasonal-Kendall trends. Furthermore, the most acidic stations showed the largest recovery from acidification during spring melt. In fact the only significant Al_{im} April trends occurred at the 2 most acidic stations. In general, there were fewer significant trends in chemistry during April compared to the entire year at every station and there were no significant trends that changed direction between the April and annual trends. We also compared annual flow-weighted mean solute concentrations at low flow, high flow, and all flow conditions to examine whether the recovery documented by seasonal-Kendall and the April Mann-Kendall trend analyses was apparent across flow conditions. The greatest increases in ANC from the beginning of the study period to the end of the study period were measured during high flow. The decrease in the number of acid episodes resulted in a decrease in Al_{im}concentrations at high flow. Perhaps the most important finding was that the frequency and magnitude of acidic episodes has decreased dramatically at the most acidic station and Al_{im} concentrations have decreased considerably during acidic episodes.

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Evaluating Potential Water Quality Impairments on National Forest Priority Watersheds Using Estimates of Atmospheric Deposition

David Levinson[1], Anita Rose[2] and Rich Pouyat[3]

The U.S. Forest Service Watershed Condition Framework (WCF) is a nationally consistent reconnaissance-level approach for assessing and classifying watershed condition, using a comprehensive set of 12 indicators that are surrogate variables representing the underlying ecological, hydrological, and geomorphic functions and processes that affect watershed condition. Primary emphasis of the WCF is on aquatic and terrestrial processes and conditions that Forest Service management activities have on stream, riparian and aquatic habitat. As part of the WCF, National Forests designate "Priority Watersheds" where a variety of land management treatments are planned and implemented. One of the primary aquatic indicators of the WCF is water quality, but measuring and monitoring water quality impacts has been difficult since many of the almost 300 Priority Watersheds are located in headwater regions on National Forests. Initial steps are under way to collocate both water and air monitoring on Priority Watersheds, to improve understanding of water quality impairments due to atmospheric deposition. A primary question is understanding when air deposition is coupled with water quality, and when they are decoupled, and why? A specific concern is Nitrogen (N) deposition, since it impacts large parts of the U.S., and initial efforts will be to use N deposition estimates to identify a subset of Priority Watersheds with potential water quality impairments for collocating air and water monitoring.

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Integration of Atmospheric Deposition and Water Quality Monitoring in the El Yunque National Forest, Puerto Rico

Anita K. Rose[1], Richard Pouyat[2], Linda Geiser[3], David Levinson[4], Chelcy Miniat[5], Bret A. Anderson[6], Helen M. Amos[7] and Denice Shaw[8]

Excess levels of nutrients (nitrogen and phosphorus) in surface water are associated with increased biological stress and decreased biological diversity. There is a significant need to enhance connections between atmospheric deposition monitoring and surface water quality monitoring to better understand linkages between air quality and the health of aquatic ecosystems. The limited integrated air/water monitoring we currently have is almost exclusively concentrated in temperate latitudes. El Yunque National Forest, Puerto Rico offers a unique opportunity to investigate air/water linkages because (1) watershed N/P loads are dominated by atmospheric inputs, (2) it already has an NADP super site, and (3) it is a tropical rainforest that experiences frequent, intense convective storms that are major source of lightning NOx. As part of WADeIn (Water Quality & Atmospheric Deposition Integration) -- an interagency collaboration improving the coordination and integration of atmospheric deposition and surface water quality monitoring to fill critical knowledge gaps about the sources, transport, and impacts of N and P -- the USDA Forest Service is proposing to install real-time water quality sensors for nutrients in the El Yunque National Forest. The goal is to integrate the resulting data with those from the NADP super site that currently exists in the National Forest. This pilot study will demonstrate the usefulness of the selected water sensors for quantification of nutrients in stream and provide quantitative information about how closely coupled stream nutrient exports are to atmospheric inputs. The window of opportunity for the El Yunque pilot is very timely and will be able to leverage a number of other pilots launching on similar timelines by other agencies and organizations. Additional benefits of the El Yunque pilot include: outreach to the local community through the El Yunque National Forest visitor center; test usefulness of sensors to be deployed as part of the recently established Watershed Condition Framework; foster collaborations between the Forest Service's National Forest System and Research and Development branches, EPA, NOAA, and USGS. Results from this pilot study will provide an opportunity to further explore integrated air/water quality monitoring, as well as provide a much needed investigation into the status of watershed/water quality in the El Yunque National Forest.

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TECHNICAL SESSION 4:
DEPOSITION MODELING AND MONITORING

Session Chairs: Anne Rea and Eric Prestbo,
USDA Forest Service and Tekran

Evaluation of Wet Atmospheric Deposition along the Coast of the Gulf of Mexico: An International Collaboration Opportunity

Rodolfo Sosa E.[1], Humberto Bravo A.[2], Ana Luisa Alarcon J.[3], Maria del Carmen Torres B.[4], Pablo Sanchez A.[5], Monica Jaimes P.[6], Elias Granados H.[7], David Gay[8], Christopher Lehmann[9] and Gregory Wetherbee[10]

The evaluation of atmospheric deposition at regional scales requires international collaboration to adequately characterize the occurrence of potential impacts and establish measures to mitigate them. The central theme for the 2017 NADP Meeting, "NADP data: making the world a better place, one monitor, one network, one study at time," gives us the direction to evaluate atmospheric deposition in the Gulf of Mexico Region.

The Gulf of Mexico Region has important sources of acid rain precursors, both on land and at sea, located in countries bordering the region, such as the USA, Mexico and Cuba. It is very important to study the chemical composition of atmospheric wet deposition through international cooperation. Studies on the Mexican coast have recorded the presence of acid rain since 2003. The aim of this study was to evaluate the major ions (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, SO_4^{2-}, NO_3^- and Cl^-), pH and conductivity in atmospheric wet deposition, collected daily from 2003 to 2015 at a sampling site located along the coast of Mexico (La Mancha, Veracruz) and compare the values with the NADP sampling sites located along the Gulf of Mexico coast from Texas to Florida.

Among the major findings: all ions were present in greater levels in "La Mancha" in comparison with each one of the sampling sites in the USA, with exception of nitrogen compounds (NO_3^- and NH_4^+), which were comparable to the USA sites. The levels of sulfates in Mexico were comparable to the highest US NADP sites. The ratio of SO_4^{2-} to NO_3^- has been used as indicator of the effectiveness of SO_2 and NOx emissions reductions in the USA. The SO_4^{2-}/NO_3^- ratio found for "La Mancha" in 2015 was 4.8, the highest value when compared to other sites in the Gulf of Mexico, which had ratios between 1.03 and 1.87. Due to the high levels of SO_4^{2-} and the ratio SO_4^{2-}/NO_3^- found at "La Mancha," it is important to monitor the sulfur dioxide emission sources in Mexico.

In addition to "La Mancha" sampling site, two additional sampling sites, in Mexico, have recently been incorporated to the atmospheric deposition study: one in the City of Campeche and another in the Port of Veracruz. Initial results from these sites will be shown.

The establishment of the international network for the evaluation of atmospheric deposition in the Gulf of Mexico represents a great opportunity for international collaboration. NADP protocols for sampling and analysis will be adopted, including quality-assurance and quality-control protocols, to ensure that information generated is comparable between current participating countries, USA and México and possibly Cuba.

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Methylmercury and Total Mercury in Marine Stratus Cloud and Fog Water: Sources, Sinks, and Lifetimes

Peter Weiss-Penzias[1], Kenneth Coale[2], Wes Heim[3], Armin Sorooshian[4], Hossein Dadashazar[5], Alex MacDonald[6], Zhen Wang[7], Ewan Crosbie[8], Haflidi Jonsson[9] and Jerry Lin[10]

Monomethylmercury (MMHg) concentrations in marine stratus cloud and fog water in California are enhanced to upwards of 1 ng L-1 compared to concentrations typically found in rain water, which are closer 0.1 ng L-1. This raises the possibility that coastal terrestrial ecosystems impacted by marine fog and clouds could be exposed to this potent neurotoxin. Efforts to measure MMHg in cloud and fog water on the California coast indicate that the source of MMHg is from evasion of dimethylmercury (DMHg) and subsequent demethylation in the air or in the droplet to form MMHg. This presentation will highlight the data collected on land, at sea, and by aircraft at numerous locations in coastal California since 2014, and discuss the major gaps in our understanding of the cycling and transport of methylated Hg compounds in the oceanic mixed layer, atmospheric marine boundary layer, and the cloud droplet.

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Trends in NADP Bromide Wet Deposition Concentrations, 2001-2016

Gregory Wetherbee[1], Christopher M.B. Lehmann, Ph.D.[2], Lee A. Green[3], Mark F. Rhodes[4], Brian M. Kerschner[5] and Amy S. Ludtke[6]

Bromide (Br^-) and other solute concentration data from wet deposition samples collected by the National Atmospheric Deposition Program (NADP) from 2001 to 2016 (study period), were analyzed for statistical trends both geographically and temporally and by precipitation type. Bromide was more frequently detected at NADP sites in coastal regions of the continental United States. The Br^- concentration data set was characterized by greater than 86 percent of sample concentrations below analytical detection. Analysis revealed that Br^- concentrations were higher in rain (only) versus precipitation containing snow. Decreasing Br^- wet deposition concentrations were observed at a majority of NADP sites over the study period; approximately 25 percent of the trend slopes were statistically significant at the alpha=0.10 level. Correlations between Br^-, Cl^-, and NO_3^- concentrations were evaluated to investigate sea-salt as a Br^- source and potential Br^- oxidation of atmospheric nitrite ($NO_{2(g)}$) to $NO_3^-{}_{(aq)}$.

Potential causes for decreasing Br^- concentrations were explored, including annual and seasonal changes in precipitation depth, reduced emissions of methyl bromide (CH_3Br) from coastal wetlands, and declining industrial use of bromine compounds. Trend analyses indicated that precipitation depth generally increased during the study period at the majority of NADP sites, which diluted Br^- below analytical detection in many samples. Declining Br^- concentrations also are consistent with declining industrial CH_3Br emissions mandated by the Montreal Protocol. Chemical processes that deplete Br^- from sea-salt aerosols and inundation of saltmarsh habitat suggest changing marine conditions were identified as possible influences on temporal trends in Br^- concentrations. There are no known ecological consequences of changing Br^- concentrations in wet deposition at this time, but the trends may help to explain the chemistry of pollutants like CH_3Br and the changing chemical climate of the atmosphere.

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Total Deposition by Measurement-model Fusion using ADAGIO

Amanda Cole[1], Alain Robichaud[2], Mike Moran[3], Mike Shaw[4], Alexandru Lupu[5], Marc Beauchemin[6], Guy Roy[7], Vincent Fortin[8] and Robert Vet[9]

Environment and Climate Change Canada's ADAGIO project (Atmospheric Deposition Analysis Generated by optimal Interpolation from Observations) generates maps of wet, dry and total annual deposition of oxidized and reduced nitrogen (N) and sulphur (S) in Canada and the United States by fusion of observed and modeled data. Optimal interpolation methods are used to integrate seasonally-averaged surface concentrations of gaseous, particulate, and precipitation species into concentration fields predicted by Environment and Climate Change Canada's in-line regional air quality model GEM-MACH (Global Environmental Multiscale model - Modelling Air quality and Chemistry). The result, a product called objective analysis (OA), corresponds to an interpolation of the difference between the modeled and measured values at network observation sites. Gas and particulate OA concentration fields are then combined with effective deposition velocities from GEM-MACH to calculate dry deposition. Similarly, OA concentrations of precipitation ions are combined with precipitation amounts from the Canadian Precipitation Analysis (CaPA) to calculate wet deposition. CaPA is also an objective analysis where all available precipitation data sets are fused with precipitation amounts predicted by GEM. Results from the 2010 development year are compared with previously-generated wet deposition kriging maps, results from the US EPA's Total Deposition (TDEP) method, and independent validation performed with surface measurements not used in the analysis where available.

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TECHNICAL SESSION 5:
URBAN AIR QUALITY AND DEPOSITION

Session Chair: Steven Decina,
Boston University

Quantifying Urban Nitrogen Emission and Deposition Through Optical Sensing Techniques

Kang Sun[1]

As the third most abundant nitrogen species in the atmosphere, ammonia (NH_3) is a key component of the global nitrogen cycle. Since the industrial revolution, humans have more than doubled the emissions of NH_3 to the atmosphere by industrial nitrogen fixation, revolutionizing agricultural practices, and burning fossil fuels. Ammonia is a major precursor to fine particulate matter ($PM_{2.5}$), which has adverse impacts on ecosystem and human health. On-road vehicles are key sources of NH_3 emissions and depositions in urban areas. Due to the successful control of oxidized nitrogen (NO_x) emissions and the lack of NH_3emission control, new vehicles manufactured now emit more NH_3 molecules than NO_x molecules. To quantify NH_3 emissions at an urban scale, a quantum cascade laser-based NH_3 sensor was integrated into a mobile laboratory, which participated in extensive field campaigns, including the NASA DISCOVER-AQ campaigns and the CAREBeijing-NCP campaign in China (400 h on-road time, 18,000 km total sampling distance). Vehicle NH_3:CO_2 emission ratios in the U.S. are found to be similar between cities (0.33–0.40 ppbv/ppmv, 15% uncertainty) despite differences in fleet composition, climate, and fuel composition. While Beijing, China has a comparable emission ratio (0.36 ppbv/ppmv) to the U.S. cities, less developed Chinese cities show higher emission ratios (0.44 and 0.55 ppbv/ppmv). If the vehicle CO_2 inventories are accurate, NH_3 emissions from U.S. vehicles (0.26 ± 0.07 Tg/yr) are more than twice those of the National Emission Inventory (0.12 Tg/yr). Vehicle NH_3 emissions are greater than agricultural emissions (which is highly uncertain as well) in counties containing near half of the U.S. population and require reconsideration in urban air quality models. Future opportunities of characterizing NH_3 emissions and investigating the transition of NH_3/NO_x regimes at the global scale enabled by satellite observations will also be discussed.

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Using Moss to Detect Fine-Scaled Deposition of Heavy Metals in Urban Environments

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Mosses are commonly used as bio-indicators of heavy metal deposition to forests. Their application in urban airsheds is relatively rare. We used moss to develop fine-scaled, city-wide maps for heavy metals in Portland, Oregon, to identify pollution "hotspots" and serve as a screening tool for more effective placement of expensive air quality monitoring instruments. In 2013 we measured twenty-two elements in epiphytic moss sampled on a 1km x1km sampling grid (n = 346). We detected large hotspots of cadmium and arsenic in two neighborhoods associated with stained glass manufacturers. Air instruments deployed by local regulators to moss-detected hotspots measured cadmium concentrations 49 times and arsenic levels 155 times the state health benchmarks. Moss maps also detected a large nickel hotspot near a forge where air instruments later measured concentrations 4 times the health benchmark. In response, the facilities implemented new pollution controls, air quality improved in all three affected neighborhoods, revision of regulations for stained glass furnace emissions are underway, and Oregon's governor launched an initiative to develop health-based (vs technology-based) regulations for air toxics in the state. The moss maps also indicated a couple dozen smaller hotspots of heavy metals, including lead, chromium, and cobalt, in Portland neighborhoods. Ongoing follow-up work includes: 1) use of moss sampling by local regulators to investigate source and extent of the smaller hotspots, 2) use of lead isotopes to determine origins of higher lead levels observed in moss collected from the inner city, and 3) co-location of air instruments and moss sampling to determine accuracy, timeframe represented, and seasonality of heavy metals in moss.

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Elemental Carbon Deposition to Urban Tree Canopies: Magnitudes and Spatial Patterns

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Urban areas are a major source of atmospheric elemental carbon (EC), a component of fine particulate matter and a powerful climate-forcing agent. However, empirical measurements of EC removal from urban atmospheres by wet and dry deposition are few in number and virtually none explicitly quantify intra-urban variability in deposition rates. Tree canopies are likely important sinks for EC on the cityscape because of their propensity to scavenge suspended particulate matter, of which EC can be a significant component in urban settings. This research aims to quantify magnitudes and spatial patterns of total (wet + dry) EC deposition to urban tree canopies in the Dallas-Fort Worth Metroplex using the throughfall method (collection of water that falls from the canopy to the forest floor). In March 2017, we established 41 throughfall collectors across a 51 km^2 area in the City of Denton, Texas. Collectors were deployed beneath 22 post oak (*Quercus stellata*) and 19 live oak (*Quercus virginiana*) trees in residential yards and urban greenspaces, both near (≤100 m) and far from roads (>100 m) with truck traffic. Additionally, 16 bulk rainfall samplers were established in grassy areas with no canopy cover. Throughfall and rainfall are currently being sampled on an event basis. Total EC deposition to urban tree canopies measured during a single rainfall event in May 2017 ranged widely, from 0.12 to 5.6 mg m^{-2}. On average, EC deposition to post oak canopies was more than 2-fold higher (1.8 ± 2.0 (SD) mg m^{-2}) compared to live oak canopies (0.67 ± 0.27 mg m^{-2}) whereas bulk rainfall deposition was 0.077 ± 0.11 mg m^{-2}. Our preliminary findings show that oak trees are effective urban air filters, removing up to 23 times more EC from the atmosphere than rainwater alone. Qualitative observations suggest that tree size and density of emissions sources within a 50-m radius buffer also contribute to spatial variability in EC deposition. Resolving surface controls on atmospheric EC removal is key to developing and assessing climate and air quality mitigation strategies.

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Characteristics and Ecological Impacts of Atmospheric Deposition in Urban and Urban-Affected Regions

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Urban air pollution causes major effects on human and ecosystem health and the environment. On-road emissions are major drivers of air quality in urban regions. Technologies for reducing NO_x emissions result in production of reduced forms of N. Industrial, urban and on-road emissions of NO_x have declined dramatically while NH_3 emissions have increased. Simulation models underestimate NH_4^+ deposition, and models and regional monitoring networks do not capture fine-scale spatial heterogeneity in dry deposition or fogwater deposition to receptor sites affected by urban emissions. The highest N deposition reported for the Western hemisphere (70 kg/ha/yr as throughfall) occurs in the San Bernardino National Forest within the eastern region of the Los Angeles Air Basin. Deposition can vary ten-fold over a 50-60 km gradient in forests downwind of Los Angeles. Contrary to previous assumptions, sulfur deposition in Los Angeles remains unusually high (30-40 kg/ha/yr), due to emissions from shipping, heavy transport and industry. Wet deposition data are of limited utility in characterizing deposition in arid regions. Notwithstanding, long-term data at the NADP site near Los Angeles (CA42) indicate decreasing temporal trends in deposition of SO_4^{2+} and NO_3^- and slightly increasing trends in NH_4^+. At several such urban-dominated NADP sites across the U.S., wet deposition switched to NH_4^+ values that are consistently greater than NO_3^- molar values during the 2005 to 2010 period. Data on urban NH_3 concentrations support this trend of increasing importance of reduced forms of N, primarily from on-road emissions of NH_3. In this light, the Lake Tahoe Air Basin case study will also be discussed.

Nitrogen critical loads in ecosystems of highly-urbanized southern California have been determined for streamwater NO_3^-, epiphytic lichen community change, vegetation type change, tree health, soil acidification and mycorrhizal responses. Urban emissions have resulted in extensive areas of CL exceedance, although agricultural emissions are also important in some locations. Urban emissions of N from Mexico City have likewise caused eutrophication impacts to forested catchments in the air basin of this megacity. Ecosystems downwind of Mexico City and Los Angeles are also exposed to phytotoxic levels of ozone---thus multipollutant effects are important in evaluating ecosystem responses to urban air pollution. Urban air pollution affects ecosystem services within the urban environment and in wildland ecosystems located within the path of urban and transport corridor plumes. Impacted services include the provision of clean drinking water and aesthetic, residential and recreational use of forests and other vegetation types.

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Assessing Sources and Fluxes of Reactive Nitrogen Deposition to Urban Landscapes Using Ion Exchange Resins

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Previous research documents that urban reactive nitrogen deposition is both higher than rural areas and spatially variable, highlighting key knowledge gaps in understanding the sources, dynamics, and overall fluxes of reactive nitrogen deposition in urban areas. Traditional methods used by the NADP NTN and US EPA CASTNET, for wet and dry deposition fluxes respectively, require considerable cost to establish and maintain, thus making it difficult to establish enough sites to fully explore this phenomenon or spatial variability. Ion exchange resins, however, offer a robust alternative as they are relatively inexpensive, integrate fluxes over many weeks without requiring exact precipitation volume, and can be used for isotopic analyses of resin eluents without fractionation. In this project, ion exchange resin columns selectively targeting nitrate (NO_3^-) or ammonia (NH_4^+) were deployed at 7 monitoring sites (5 urban and 2 rural) around Pittsburgh and the nearest NTN-CASTNET site and were exchanged every 1-2 months over a one-year period. Column eluents were analyzed for concentrations of NO_3^- and NH_4^+ to calculate deposition fluxes, as well as dual nitrate isotopes ($\delta^{15}N$, $\delta^{18}O$) to examine emission sources and oxidation chemistry. Fluxes were compared to those recorded by NTN and CASTNET at the nearest rural national monitoring sites to verify that the ion exchange resins are capturing the same signal as the established networks. Contrary to previous research, preliminary results indicate no significant differences in deposition fluxes between urban and rural sites for either NO_3^- or NH_4^+. $\delta^{15}N$ and $\delta^{18}O$ values of eluted NO_3^- were highly variable among network sites where both $\delta^{15}N$ and $\delta^{18}O$ values are generally higher in winter than summer. The range in $\delta^{15}N$ and $\delta^{18}O$ values and the seasonal patterns are consistent with prior reports linking temporal patterns in $\delta^{15}N$ with increased power plant emissions during the winter months and $\delta^{18}O$ value with seasonal changes in oxidation chemistry. This research seeks to narrow existing knowledge gaps regarding the fluxes of reactive nitrogen deposition to landscape, and how the high degree of spatial variability observed in urban systems is related to NO_X and NH_3 emission sources. The preliminary results reported here demonstrate the need for finer spatial scale sampling to further understand causes of site variability, as well as the potential for ion exchange resins to be used as a tool for this type of analysis.

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Increasing Ethanol Consumption as a Renewable Fuel: How Will Vehicle Ethanol Emissions Impact the Urban Atmosphere?

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US ethanol fuel consumption has increased exponentially over the last two decades as part of a movement to reduce greenhouse gas emissions and become more fuel independent. US annual renewable fuel production is ~16 billion gallons and is required to increase to 36 billion according to the renewable fuel standard. Regardless of the technology or feedstock used to produce renewable fuel, the primary end product will be ethanol. This has spurred extensive debate among a diverse array of US stakeholders about the practicality of the renewable fuel standard. Much of the evidence for both sides of the debate relies on the life cycle analysis of ethanol production and weighing the effects of ethanol production on our economy, environment, and food and water supply. However, one principal uncertainty not adequately addressed by either side in this debate is "What are the impacts of increasing ethanol fuel consumption and subsequently ethanol and aldehyde emissions on atmospheric composition and chemistry?" This is despite modeling efforts that predict increases in blended fuel consumption will increase national average ozone concentrations. This is especially true for urban air sheds consisting of blended fuel vehicle emissions that result in elevated concentrations of VOCs with relatively high ozone reactivities (i.e. aldehydes, alcohols).

The presented work provides evidence of high ethanol atmospheric concentrations associated with densely populated urban areas and ethanol refineries throughout the globe by measuring wet deposition ethanol concentrations. This has also produced the first global deposition flux of ethanol (2.4± 1.6 Tg/yr) based on empirical data and suggests wet deposition removes 6 to 17% of atmospheric ethanol annually. To provide further evidence of the increasing anthropogenic sources leading to higher atmospheric ethanol concentrations, a method to measure the carbon isotopic composition of ethanol at natural abundance levels was developed and carbon isotope signatures ($\delta^{13}C$) of vehicle ethanol emission sources are reported for both Brazil (-12.7‰) and the US (-9.8‰). An isotope mixing model using vehicle and biogenic endmembers was used to estimate ethanol source apportionment in wet deposition and results suggest anthropogenic sources contribute up to 7X more ethanol than previously predicted in modeled ethanol inventories. With the US renewable fuel standard requiring a substantial increase in the next five years, it is essential that the entities involved in deciding the fate of US fuel consumption have knowledge of all the advantages and disadvantages of increased ethanol consumption, including the atmospheric impacts of ethanol fuel emissions.

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TECHNICAL SESSION 6:
NITROGEN: TRANSPORT DEPOSITION AND EFFECTS

Session Chair: Justin Valliere
University of California Los Angeles

Ecosystem Flip-Flops in Response to Anthropogenic N Deposition: The Importance of Long-term Experiments

George Vourlitis[1]

Anthropogenic nitrogen (N) deposition has the capacity to alter terrestrial ecosystem structure and function; however, short-term (months-years) responses may be fundamentally different than long-term (years-decades) responses. Here the results of a 14 year field N addition experiment are reported for two semi-arid shrublands, a post-fire chaparral and a mature coastal sage scrub (CSS), located in San Diego County, California that have been exposed to 50 kgN ha^{-1} yr^{-1} since 2003. Since >90% of the anthropogenic N in this region consists of dry deposition, N was added during the late-summer or early-fall each year to assess how dry N inputs alter ecosystem processes. Both shrublands experienced complete "flip-flops" in their response to experimental dry N inputs. For example, post-fire chaparral plots exposed to added N had significantly lower net primary production (NPP) than control plots over the first 3 years of the experiment, but thereafter, the NPP in N plots increased consistently each year and became significantly higher than in control plots after 7 years of N fertilization. In CSS, NPP and the abundance of Artemisia californica, a co-dominant shrub, increased significantly in N plots over the first 6 years, but thereafter, NPP and the abundance of A. californica and Salvia mellifera, the other co-dominant shrub, declined, and now the N plots have a lower NPP and are dominated by the invasive annual Brassica nigra. These transient responses, and interactions between N accumulation and other factors such as post-fire succession (chaparral) and chronic drought (CSS), would have been missed if the experiment was ended after the end of a typical funding cycle, highlighting the importance of long-duration field experiments in assessing ecosystem responses to chronic N enrichment.

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Organic Nitrogen in Aerosols at a Forest Site in Southern Appalachia

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This study investigates the composition of organic particulate matter ($PM_{2.5}$) in a remote montane forest in the southeastern U.S., focusing on the role of organic nitrogen (N) in sulfur-containing secondary organic aerosol (SOA) and aerosols associated with biomass burning. Measurements targeted four groups of compounds: 1) nitro-aromatics associated with biomass burning; 2) organosulfates and nitrooxy organosulfates produced from biogenic SOA precursors (i.e., isoprene, monoterpenes and unsaturated aldehydes); 3) terpenoic acids formed from monoterpene oxidation; and 4) organic molecular markers including methyltetrols, C-5 alkene triols, 2-methylglyceric acid, 3-hydroxyglutaric acid and levoglucosan. Terpenoic acids and organic markers were included to assist in characterizing the extent of biogenic compound oxidation and atmospheric processing (i.e., aerosol aging) as well as contributions from biomass burning sources.

The average fraction of WSON in water soluble total nitrogen (WSTN) exhibited a pronounced seasonal pattern, ranging from ~18% w/w in the spring to ~10% w/w in the fall. Nitro-aromatic and nitrooxy-organosulfate compounds accounted for as much as 28% w/w of WSON. Oxidized organic nitrogen species showed a maximum concentration in summer (average of $0.65 ngN/m^3$, maximum of $1.83 ngN/m^3$) consistent with greater relative abundance of aged biogenic SOA tracers (higher generation oxygenated terpenoic acids). Highest concentrations of nitro-aromatics (eg. Nitrocatechol and methyl-nitrocatechol) were observed during the fall season associated with aged biomass burning plumes. Isoprene derived organosulfate (MW216, 2-methyltetrol derived), which is formed from isoprene epoxydiols (IEPOX) under low Nox conditions, was the most abundant individual organosulfate. Although nitro-aromatics and nitrooxy organosulfates account for a small fraction (seasonal averages of 1.0 to 4.4%) of WSON, our results provide insight into atmospheric formation processes and sources of these largely uncharacterized organic nitrogen species.

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Quantifying Nitrogen Deposition Inputs and Impacts on Plant Richness in a Mediterranean-type Shrubland

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Human activities have contributed to increased nitrogen (N) availability in terrestrial ecosystems worldwide due to atmospheric pollution and resulting N deposition. Previous work in coastal sage scrub (CSS) of southern California has established a clear link between elevated N deposition and negative ecological impacts on native vegetation. However, while declines in plant richness have been observed under high N deposition in a number of ecosystems worldwide, studies examining this relationship in CSS are severely lacking. We measured levels of N pollutants in the atmosphere and determined rates of N deposition across the landscape based on atmospheric concentrations, deposition velocities of different reactive N forms, leaf area index and plant stomatal uptake. We also measured soil N availability and plant community composition of CSS at thirty sites across the Santa Monica Mountains in an effort to explore relationships between plant richness and cover with atmospheric N inputs. We predicted elevated rates of N deposition would be associated with lower plant diversity and higher cover of nonnative species. Consistent with these hypotheses, we demonstrate that N deposition is associated with reduced plant richness and slight increases in nonnative cover across the Santa Monica Mountains. We also show through a number of field and greenhouse experiments that declines in native species may be driven by changes to plant-water relations, altered plant-soil feedbacks, and contrasting plant functional traits in native and invasive species. As human activities continue to alter global N cycling, efforts to conserve native ecosystems will require explicit consideration of atmospheric N deposition.

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TECHNICAL SESSION 7:
NITROGEN: TRANSPORT DEPOSITION AND EFFECTS (CONTINUED)

Session Chair: Justin Valliere,
University of California Los Angeles

Atmospheric Deposition Evaluation as a Tool to Preserve Urban Natural Green Areas: Mexico City Case

María Alejandra Fonseca[1], Julio Campo[2], Luis Zambrano[3], Rodolfo Sosa[4], Ana Luisa Alarcón[5], María del Carmen Torres[6], Pablo Sánchez[7], Olivia Rivera[8] and Mónica del Carmen Jaimes[9]

United Nations data indicate that by the year 2030, approximately 60% of the world's population will live in urban areas. Within urban ecosystems, the anthropogenic pollutants emissions in the atmosphere are concentrated and intensified, mainly linked to economic activities. Since most of these pollutants are harmful to humans, its reduction in the environment is a topic of international, national and local interest. It is important to note that mitigating these emissions is also vital for the conservation of urban natural green areas, which at the same time provide ecosystem services to cities.

Mexico City Metropolitan Area (MCMA) has a dynamic population of more than 20 million inhabitants being the twelfth largest city in the world and as all megacities faces great challenges in which it refers to environmental sustainability and quality of life of its inhabitants. Actually, MCMA has 23 urban natural green areas and a community area corresponding to 26,047 ha with ecological conservation status (it corresponds to 17.42% of the city territory of 148,500 ha) which offer various ecosystem services such as aquifer recharge, greenhouse gas fixation, climate regulation, agricultural production, noise control, CO2 fixation, local wildlife reservoir, both flora and fauna, and of course, and not least important, recreational and cultural activities. That is why it is essential to evaluate the quality of the atmospheric deposition that is presented in this megacity, to maintain the conservation and management of these natural protected areas. Fortunately, the city is provided with a network of monitoring atmospheric deposition (REDDA) that uses semi-automatic equipment for the collection of dry deposition and wet deposition samples at 16 sampling sites. Some of these monitoring sites are within natural urban areas. The operation of this network is in collaboration with the Government of Mexico City with the Center for Atmospheric Sciences of the National Autonomous University of Mexico.

The most important findings in relation of the atmospheric deposition evaluation in MCMA include:

The pH values of the samples at the stations located in the south were more acidic than the samplesfor the stations in the north. It is important to mention that in the south part of the MCMA is where most of the urban natural green areas are located.

These results are in line with meteorological conditions, prevailing winds blowing from the north to the south, as well as emission sources located in the north sector.

In most study sites, annual volume weighted decreased from 2003 to 2014. For example, "Montecillos" station located in the North in a rural area, values decreased from 7.48 in 2003 to 5.03 in 2014.

In the stations located in a rural area ("Montecillos" in the North and "Ajusco" in the South), a strong correlation was found between NH4+ and SO42-, NO3-, and Cl-; this is likely due to their origin in soil (i.e., fertilizer use). The same concentration trend was observed for SO42- and NO3- in the MCMZ stations; this indicates that the sources of acid rain precursors are upwind (i.e., to the north) of the study area.

It is important to take advantage of the information generated by the existing network and, if necessary, increase the number of sites to generate information for the integral decision-making on the quality of life of people in MCMA and the conservation of the urban natural green areas, as well as studying the critical loads that occur in megacities with local and global impact.

The actions described will help to establish an integral monitoring of the natural components of the urban ecosystem that consider the potential impact of atmospheric deposition in soils, water bodies, flora and fauna, etc.

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Spatial and Temporal Relationships of Key Nitrogen Species between Ambient and Deposition Regimes

Richard Scheffe[1]

There is increased interest in addressing adverse ecosystem effects associated with nitrogen deposition through the secondary National Ambient Air Quality Standards (NAAQS). The NAAQS structure raises interesting challenges in bridging ambient and deposition space while imposing some constraints on biologically active forms of nitrogen that may not explicitly be considered a NAAQS specie. This presentation explores two "NAAQS" bridging constructs – transference ratios and the delineation of particulate ammonium contribution to wet deposition – through a series of three dimensional spatial analyses across a variety of Federal Class 1 and Ecoregion Level 3 areas based on a time series of 2002 -2012 CMAQ air quality simulations that underpin the TDEP deposition surfaces. These analyses are used to better understand the limits of using surface level indicators, associated with ground based monitoring systems, intended to capture processes through the entire atmospheric column.

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Nutrient Deposition in the Headwaters of Streams may Impact Nitrogen Loading in Southern Californian Estuaries

Pamela Padgett[1], Karen McLaughlin[2] and Martha Sutula[3]

As has been shown for other estuarine ecosystems, roughly a quarter of the total N and P load in Southern California coastal waters cannot be accounted for by known anthropogenic sources. Although the contribution of deposition to estuarine nutrient loads has been demonstrated in other regions, it is has not been well characterized in California. In particular, little data are available on the dry N and P deposition. Studies were conducted to address the following research objectives:

1. Identify methods for measuring dry deposition controlled fumigation systems. These included water surface samplers and acid impregnated filters and Nylasorb filters.
2. Estimate the spatial and temporal variability in N and P deposition to five, undisturbed feeder catchments.
3. Evaluate the utility of dual isotopes: (δ^{18}O and δ^{15}N) to assess the contribution of atmospheric NO_3^- to streams.

Of the surrogate surfaces tested in fumigation chambers, the water surface samplers produce the most reliable results for both NO_3^- and NH_4^+. They demonstrated a strong linear relationship with air concentrations. For the Nylasorb filters the linear relationship was weaker, and the flux of HNO_3 was significantly less than to water samplers. Citric acid impregnated filters were poor passive samplers for NH_4^+, but oxalic acid impregnated filters were satisfactory under controlled fumigations. Under field conditions, the water samplers had limited usefulness due to as evaporation and freezing, Nylasorb prove more robust under field conditions.

The average N dry deposition was ~70% of, and the average P dry deposition is ~30% of the total load. An important finding was that at several sites NH_3^+ was a more dominant N component of both wet and dry deposition than was expected. Water surface sampler deposition data show that in general, NH_4^+ dry deposition is nearly twice as high as NO_3^- and at some sites NH_4^+ wet deposition also dominated the N deposition pool. The prevalence of NH_4^+ is likely due to the proximity of agriculture even in an area of moderately high traffic.

The high δ^{18}O value for atmospheric NO_3^- across all sites suggests that the dual isotopic composition of NO_3^- could be a useful tracer for atmospheric N deposition. However, dissolved NO_3^- in streams did not reflect the isotopic composition of atmospheric NO_3. This was not surprising given the relatively small surface area of headwater streams. Atmospheric deposition of nutrients is more likely indirectly accumulated in streams, following deposition to other surface before entering the streams through surface and subsurface runoff.

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Contributions of Organic Nitrogen to the Gas Phase and Speciation of Amines in Ambient Samples

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Atmospheric reactive nitrogen is a mixture of inorganic compounds like NOx, nitric acid, ammonia, nitrate, and ammonia and organic compounds that contain nitrogen. There is significant uncertainty in the contribution of organic nitrogen compounds to the atmospheric reactive nitrogen budget and the deposition budget. Amines are a class of compounds known to be present in both the gas and aerosol phase but measurements of their abundance and speciation are limited. We have developed an ion chromatography method using a Dionex CS19 column with conductivity detection which can speciate more than 10 different amine compounds including the methyl and ethyl amines. A number of amine compounds were detected in variety of ambient filter and denuder samples analyzed and these results will be presented. The sampling efficiency of several amine compounds will be determined. Additionally, recent papers by Matsumoto and Yamato describe a method to determine the basic and acidic organic nitrogen contribution using a denuder sampling technique. In this work, we test this method in the laboratory and with samples collected in Rocky Mountain National Park. Results of laboratory testing examine carryover between the sodium carbonate denuder used for nitric acid determination and "acidic organic nitrogen" and the phosphorous acid coated denuder used for ammonia determination and "basic organic nitrogen". The contribution of "basic organic nitrogen" and "acidic organic nitrogen" will be presented for select periods of sampling in Rocky Mountain National Park.

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TECHNICAL SESSION 8:
AMMONIA EMISSION, TRENDS, DEPOSITION

Session Chair: Katie Benedict,
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Investigation of Hourly Concentration Ratios of Ammonia Gas and Particulate Ammonium at CASTNet Site in Beltsville, MD

Greg Beachley[1], John T. Walker[2], Gary Lear[3] and Melissa Puchalski[4]

The chemical composition of atmospheric nitrogen pollution has shifted from predominantly oxidized nitrogenous species (particulate NO_3^- and gaseous NOx) to reduced inorganic nitrogen (particulate $NH_4^+$and gaseous NH_3) (Li et al., 2016, Du et al., 2014). Understanding the particle formation chemistry and the transport of nonpoint source (i.e. fertilizer application, animal operations) emissions is key in assessing NH_3 bidirectional air-surface exchange, deposition, and subsequent ecological impacts. Currently, national air monitoring networks are situated for measuring integrated reduced nitrogen samples often collected for periods of a week or more. These measurements are typically filter-based and can suffer from volatilization losses especially for ammonium nitrate.

The EPA's Clean Air Status and Trends Network (CASTNET) has operated co-located Monitor for Aerosols and Gases (MARGA) online analyzers at Beltsville, MD for a long-term period (spanning from July 2013 to July 2015 and including the Fall of 2016) in order to assess the precision of the analyzers as well as the efficacy of co-located weekly integrated filter pack measurements. The MARGAs hourly samples include both NH_4^+ and NH_3 in addition to nitrate (NO_3^-), sulfate (SO_4^{-2}) and their acid gas precursors (HNO_3 and SO_2) and base cations (Ca^{+2}, Na^+, Mg^{+2}, K^+). The MARGAs sampled approximately 13-months of valid data, capturing all seasons at a site located in crop fields managed by USDA's Agricultural Research Service. There is a need to better understand hourly NH_3:NH_4^+ chemistry and a need to better characterize long-term measurements of these compounds that are deployed in national networks (CASTNET, NADP's AMoN, IMPROVE). This communication will explore daily and seasonal trends along with analysis of episodic events of NH_3 and NH_4^+ using the entire suite of MARGA measurements and co-located meteorological measurements.

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Urban and On-Road Emissions: Underappreciated Sources of Atmospheric Ammonia

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As a result of over-reduction of nitrogen oxides, light and medium duty vehicles and newer heavy duty vehicles on U.S. roadways emit significant levels of ammonia (NH_3). Herein we provide updated spatial distribution and inventory data for on-road NH_3 emissions for the continental U.S. On-road NH_3 emissions in urbanized regions are typically 0.1 – 1.3 t/km2/yr. By comparison, NH_3 emissions in agricultural regions generally range from 0.4 – 5.5 t/km2/yr, with a few hotspots as high as 6 – 11 t/km2/yr. We have identified 500 counties that receive at least 30% of the NH_3 emissions from on-road sources. Counties with higher vehicle NH_3 emissions than from agriculture include 41% of the U.S. population. Within CONUS the percent of wet inorganic N deposition from the NADP/NTN as NH_4^+ ranged from 37 to 83% with a mean of 59.5%. Only 13% of the NADP sites across the U.S. had less than 45% of the N deposition as NH_4^+ based on data from 2014-2016, illustrating the near-universal occurrence of NH_4^+ deposition across the United States, regardless of the primary sources of NH_3 emissions.

In four urban sites in Oregon and Washington the NH_4-N:NO_3-N ratio in throughfall averaged 1.0 (range of 0.8 – 1.3) compared to an average ratio of 2.3 in bulk deposition (range of 1.8 – 2.9) measured in open canopy-free areas. In bulk deposition at urban sites in the LA Basin deposition of NH_4-N and NO_3-N were highly similar to each other. Ratios of NH_4-N:NO_3-N in throughfall under shrubs in the Los Angeles Air Basin ranged from 0.7 to 1.5 across a spatially extensive network of chaparral and coastal sage scrub sites with high but varying degrees of urban influence. The NH_4-N:NO_3-N ratio at ten sites in the Lake Tahoe Basin averaged 1.4 and 1.6 in bulk deposition and throughfall, respectively. The ratio in throughfall at Valhalla, immediately adjacent to the city of South Lake Tahoe, was 1.9. Annual throughfall deposition and bulk deposition of NH_4-N was strongly correlated with summertime NH_3 concentrations in the Tahoe Basin. Values of $\delta15NH_4^+$ in bulk deposition and throughfall samples in the Tahoe Basin were predominantly within the range of -5.0 to -0.9‰, indicative of tailpipe NH_3 emissions. The relative importance of urban and on-road NH_3 emissions versus emissions from agriculture varies regionally. In some areas both are important and should be considered when evaluating the principal sources of N deposition to affected ecosystems.

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“Fingerprinting” Vehicle Derived Ammonia Utilizing Nitrogen Stable Isotopes

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Ammonia (NH_3) is the primary alkaline molecule in the atmosphere and plays a key role in numerous atmospheric processes that have important implications for human health and climate control. While agriculture activities dominate the global NH_3 budget, there are large uncertainties in the urban NH_3emission inventories. The analysis of the nitrogen stable isotope composition of NH_3 ($\delta^{15}N$-NH_3) might be a useful tool for partitioning NH_3 emission sources, as different emission sources tend to emit NH_3 with distinctive $\delta^{15}N$ signatures or “fingerprints”. This novel tool may help improve upon urban emission inventories, which could help to improve modeling of important atmospheric processes involving NH_3. However, there is a current lack of $\delta^{15}N$-NH_3 measurements of potentially important urban NH_3 emission sources, and many of the reported NH_3 collection methods have not been verified for their ability to accurately characterize $\delta^{15}N$-NH_3.

Here we present a laboratory tested method to accurately measure $\delta^{15}N$-NH_3 using honeycomb denuders coated with a 2% citric acid solution. Based on laboratory tests, the NH_3 collection device has been optimized under a variety of conditions. Near quantitative NH_3 collection is found at a sampling rate of 10 SLPM for NH_3 concentrations less than 2 ppm_v, and $\delta^{15}N$-NH_3 precision is found to be approximately 1.0‰. This newly developed NH_3 collection device for isotopic characterization has been applied to improve our understanding of the $\delta^{15}N$-NH_3 signatures from vehicles. Preliminary results of NH_3 collected near a road-side indicate an average $\delta^{15}N$-NH_3 of -2.1 ± 1.9‰. This work is ongoing, and plans are in place to collect NH_3 directly from tailpipes and from on-road air. Our preliminary results indicate that vehicle derived NH_3 has a distinctive $\delta^{15}N$ signature compared to agricultural and waste emissions; thus, $\delta^{15}N(NH_3)$ has the potential to be used to understand urban NH_3 emission sources.

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POSTER SESSIONS

IN ALPHABETICAL ORDER BY AUTHOR

Measurement of Air-Surface Exchange of Speciated Nitrogen and Sulfur Compounds in a Coastal Environment

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Ecosystem exposure and vulnerability to atmospheric deposition of nitrogen and sulfur compounds is assessed by the United States Environmental Protection Agency's (U.S. EPA's) primary regulatory tool, the Community Multiscale Air Quality Model (CMAQ). Observational datasets are required for the development of the dry deposition algorithms used in CMAQ. These deposition datasets are influenced by local environmental conditions such as meteorology, atmospheric chemistry, and surface conditions. There is a paucity of direct deposition datasets in coastal environments, which often have different environmental conditions than inland locations.

This study builds on the previous work of Rumsey and Walker, 2016 to deploy the Monitor for AeRosols and GAses (MARGA) to directly measure hourly fluxes of gases (NH_3, HNO_3, HNO_2, and SO_2) and aerosols (NH_4^+, NO_3^-, and SO_4^{2-}) above a grassy field. The MARGA on-line ion-chromatography analyzer was deployed in the same setup with two samplers at 4-m and 1-m to directly measure concentration gradients over a grassy field in a coastal environment near Charleston, South Carolina from mid-May through June 2017. The multi-species concentration gradient measurements are used in conjunction with the micrometeorological aerodynamic gradient method to determine air-surface exchange fluxes for each species to further characterize dry nitrogen and sulfur deposition processes in a coastal environment and assess how they differ from inland deposition processes. This communication highlights preliminary results for species concentration gradients and meteorological data measured this summer.

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Measuring Low-Level Concentrations of Trace Metals in Wet Deposition Samples

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Trace metals are released into the environment via natural and anthropogenic processes. Metals such as Al, Mn, Fe, Cr, Ca^{2+} and K^{+} are indicative of soil contribution. The Earth's crust is enriched with many of these elements and Aeolian dusts can efficiently transport some crustal elements and heavy metals. Non-crustal volatile metals, such as Cd, Zn, and Pb are characteristic of fuel combustion and metal smelting. The Central Analytical Laboratory (CAL) has come up with a method to measure low level concentrations in wet deposition samples via Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES).

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First Diagnosis of Allergenic Airborne Pollen and its Interaction with Atmospheric Pollutants in the Mexico City Metropolitan Zone (MCMZ) and their Transport and Dispersion in the Atmosphere

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Air pollution is one of the main characteristics of areas where human population density is very high; It plays an important role in the health of the entire population. In addition to the atmospheric pollutants (gases and particles) emitted by human activities, the atmosphere is the transport medium for a wide variety of biogenic particles. These include bioaerosols such as viruses, bacteria, fungi, plant fragments, pollen grains, their allergenic proteins or small airborne particles containing pollen allergens.

Atmospheric pollutants have direct effects on pollen, modifying their biological and reproductive functions, causing a decrease in viability and germination; alteration of the physicochemical characteristics of the pollen surface and its allergenic potential and adjuvant effect, increasing the potential risks to health. It has been reported that pollutants such as O_3, NO_2, SO_2 and atmospheric deposition (wet and dry) interact with allergenic pollen in the atmosphere aggravating asthma symptoms and particulate matter together with pollen allergens play a very important role in increasing the allergic inflammatory response. Therefore, the objective of this work was to perform a first diagnosis of airborne allergenic pollen from MCMZ, its interaction with atmospheric pollutants and their transport and dispersion in the atmosphere. Sampling of air pollen grains was carried out at four city stations belonging to the Mexican Aerobiology Network (REMA) during the period 2014 to 2016. Records of atmospheric pollutants and meteorological conditions, including wind fields, were analyzed for the same study period. The first spatial-temporal interpretation (diurnal and seasonal cycle) was performed among all variables evaluated, their transportation through the atmosphere of Mexico City and the risk to the health of the population were determined.

In this study, spatial and temporal variations in the air quality (RAMA Network) and chemical composition of rain (REDA Network) in Mexico City between 2014 to 2016 were analyzed. Major ions (Na^+, NH_4^+, K^+, $Mg^{2+,}$ Ca^{2+}, SO_4^{2-}, NO_3^- and Cl^-), pH, and electrical conductivity (EC) were analyzed weekly at 4 sampling stations located in the same region MCMZ.

Spatial distribution of wet atmospheric deposition shows that pH decreases throughout the study from north to south in the MCMZ.

In the stations located in a rural area, a strong correlation was found between NH_4^+ and SO_4^{2-}, NO_3^-, and Cl^-; this is likely due to their origin in soil (i.e., fertilizer use).

The same concentration trend was observed for SO_4^{2-} and NO_3 in the MCMZ stations; this indicates that the sources of acid rain precursors are upwind (i.e., to the north) of the study area.

Considering that external emission sources play a decisive role in driving acid rain within the MCMZ, it is necessary to establish strategies for the emission reductions of acid rain precursors from upwind sources outside the MCMZ.

This shows the need to continue multidisciplinary studies as well as to expand the interaction among the different available networks: REMA, REDA and RAMA

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Live Demo: Critical Loads Mapper Tool

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The Critical Loads Mapper Tool is a EPA-USFS-NPS collaborative effort to enable decision makers, researchers, and the public to easily access information on atmospheric deposition of nitrogen and sulfur, critical loads, and their exceedances to better understand local and regional vulnerability to atmospheric pollution. This interactive mapping tool displays nitrogen and sulfur deposition levels through time for several air quality models, critical load levels for terrestrial and aquatic ecosystems in the National Critical Loads Database, and the exceedance of deposition over the critical loads as an estimate of vulnerability to air pollution.

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The Geospatial Monitoring of Air Pollution (GMAP) and its Role in Addressing Critical Scientific Knowledge Gaps in Air Quality and Source Emissions

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The U.S. EPA Geospatial Mapping of Air Pollution (GMAP) project has been utilized to determine stationary sources' influence on surrounding air quality. The mobile GMAP platform allows for air quality monitoring at ~1 sec resolution coupled with mobile 2D anemometer measurements (vehicle speed corrected) and real-time GPS coordinates. Additionally, stationary measurements are able to be conducted to determine source apportionment influences on monitor readings. Currently, the GMAP system is equipped with a cavity ring-down spectroscopy (CRDS) that is able to measure hydrogen sulfide (H_2S) and methane (CH_4) and a multi-pass UV optical spectrometer that can measure benzene-toluene-ethylbenzene-xylene (BTEX), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), ozone (O_3), formaldehyde, and styrene. During stationary measurements, a 3D anemometer is also attached to provide 3D wind measurements used to determine emissions flux estimates from ground level emission sources.

The GMAP platform has primarily been utilized to assess air quality impacts near facilities such as landfills, wastewater treatment centers, oil and gas processes, and paper mills. With the importance of ammonia (NH_3) as a precursor in particulate matter (PM) formation and the growing regulatory interest of decreasing NH_3 emissions to limit PM pollution in the U.S., the mobile geospatial measurement systems may be useful in both quantifying emission rates and assessing plume size and variability, helping to fulfill critical knowledge gaps of NH_3 emissions and their role in regional PM concentrations. CRDS instruments are able to measure air pollutants at a high degree of accuracy and precision with a relatively low residence time. NH_3-measuring instrumentation is being explored as a possible addition to the GMAP system.

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Wet and Dry Deposition of Excess Chloride near a Hardrock Salt Mine

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A preliminary study was undertaken to assess both wet and dry deposition of chloride in the vicinity of an active salt mine in Lansing, NY. Multi-day sampling of 3 wet events and 3 dry events were undertaken using triplicate NADP sampling buckets over a 5 station transect from 244 m to 600 m from the salt pile storage facilities at the mine. A 6th, control site was located 4100 m from the salt piles. Overall wet and dry deposition rates were estimated for each site using a random effects model. Similar analyses were performed on the conductivity of the wet samples, and dry samples with a standard addition of deionized water added to the dry sample buckets after collection. The transect was arranged north of the mine and deployments were attempted when forecasts predicted that the transect area was going to be downwind of the mine, at least some of the time.

Summary results show the control site having an average daily wet deposition of 3.2 ±22.3 (s.e.) mg Cl-/m2 and a daily dry deposition of 3.1 ±22.5 mg Cl-/m2. Stations 1 through 4, located 250 to 550 m from the salt piles, show a 40 to 75-fold increase in wet deposition and a 19 to 41-fold increase in the mean daily dry Cl- deposition, compared to the control site.

Combining wet + dry deposition on an annual basis, Cl- deposition was 25 to 48 times greater than the control site for stations #1 through #4. Annual NaCl total deposition in kilograms per hectare were: Station #1, 904; #2, 837; #3, 725; #4, 470; and #5, 342, with a standard error of ~ ±20%. Our control location yields an annual deposition rate of only 19 kg NaCl/ha. There is an excess of NaCl deposition of 61 metric tons/yr for the 235 hectare area within a 500 m radius of the salt piles. Within a 1 km radius of the salt piles, the excess NaCl deposition is 99 metric tons per year. These data suggest substantial excess chloride deposition to the surrounding landscape, especially within ½ km of the salt piles. Visible damage to local vegetation and excess corrosion of metal nearby most likely from excess salt deposition, corroborates these findings.

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Acidification and Climate Drive Increased Dissolved Organic Carbon in High Elevation Lakes

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Increasing concentrations of dissolved organic carbon (DOC) in the northeastern US have been attributed to two potential mechanisms: recovery from acidification and changing climate. Due to geology and landscape setting, Maine's high elevation lakes (>600m) provide unique insight into the response of surface water chemistry to declining acidic deposition and interannual climate variability. Long-term geochemical response in 29 lakes was analyzed during 30 years of change in sulfate (SO_4^{2-}) deposition and climate. All 29 lakes exhibited positive trends in DOC from 1986-2015, and 19 of 29 (65%) lakes had statistically significant increases in DOC throughout the study period. These results illustrate a region-wide change from low DOC lakes (<5 mg/L) to moderate DOC lakes (5-30 mg/L). Increasing DOC trends were more consistent across high elevation lakes than in previous studies from lower elevation lakes in the northeastern US. Net increases in DOC concentrations were correlated with net decreases in SO_4^{2-}, and a direct comparison of high elevation and low elevation lakes in Maine revealed greater extent of acidification and larger increases in DOC concentrations in high elevation lakes. A linear mixed effects models demonstrated that SO_4^{2-} and climate variables describe most of variability in DOC concentrations ($r^2 = .78$). The strongest predictor of DOC concentration was an inverse relationship with SO_4^{2-} ($p < 0.0001$). Coefficient of variation (CV) of DOC in all lakes was negatively correlated with air temperature, suggesting a homogenous DOC response to increasing temperature. Due to SO_4^{2-} concentrations trending towards pre-acidification levels and projections of a warmer, wetter, and more variable climate, there is uncertainty for the future trajectory of DOC trends in surface waters. Given the importance of DOC to lake biogeochemistry, long-term monitoring of Maine's high elevation lakes is increasingly important to understand both recovery and response in surface water chemistry to a changing chemical and physical environment in the decades ahead.

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Selecting Critical Loads of Atmospheric Deposition when the Response is Continuous: A Case Study of Risk Assessment to Lichens

Linda Geiser[1], Heather Root[2], and Peter Nelson[3]

Empirical responses of terrestrial and aquatic organisms to the deposition of acidifying and eutrophying air pollutants are often continuous. Whether the response metric be community composition, growth rate, seedling survival, or something else, the absence of a discontinuity signaling an obvious exceedance of a biological response threshold can make critical load selection annoyingly subjective. How, by gum, does one evaluate harm—is even the smallest measurable amount of change harmful? Here we share some ideas for assessing risk associated with depositional loadings of 1.5, 2, 2.5, and 3 kg S and N ha-1 yr-1 to five lichen community indices: sites scores calculated as the abundance weighted mean sensitivity of species present; total species richness; forage lichen richness; cyanolichen richness; and sensitive species richness. We use national-scale data to show how risk assessments can help managers select a geographical-, climate-relevant critical load and explain the potential harm associated with its exceedance.

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A Pilot Study of the Radiello Passive Ammonia Samplers at Three Canadian (CAPMoN) Sites with Comparisons to Continuous Measurements and Satellite Retrievals

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The Canadian Air and Precipitation Monitoring Network (CAPMoN) has increased its efforts in monitoring of ammonia by establishing three sites in central and eastern Canada to test the effectiveness of the AMoN Radiello passive ammonia samplers for potential inclusion into the mainstream CAPMoN suite of measurements. Three evaluation sites, Kejimkujik, Nova Scotia and two Ontario sites at Bonner Lake and Longwoods all began sampling in October 2013. The data presented in this poster examines the annual cycles, the application of a temperature adjustment to account for the extended temperature range of measurements and also establishing a method detection limit (MDL). In addition, some of the challenges encountered with the application of travel and lab blanks to the data records will also be examined and presented. In March 2017 the two Ontario sites were moved to Saskatchewan (Flat Valley and Pinehouse Lake) where the Radiello samplers are collocated with continuous ammonia monitoring instruments. This move was facilitated to extend the study by adding the comparison of these bi-weekly aggregate values to the continuous measurements using a modified Thermo 42i-TL instrument and a Picarro G2103. The two week integrated values from the Radiello are compared with an equivalent bi-weekly integrated record from the continuous measurements. In turn, these records are compared to Cross-track Infrared Sounder (CrIS) satellite ammonia retrievals both as the integrated values and as discrete point-to-point comparisons during each satellite overpass. Preliminary results will be presented.

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Glyphosate: Understanding its Atmospheric Transport and Fate

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Glyphosate is a widely used agricultural chemical in the United States. It's an environmental contaminant of concern as a suspected carcinogen, although an evaluation of its health effects is ongoing. There is a need to better understand its transport and fate in the environment, particularly in sensitive ecosystems. Glyphosate is non-volatile and sorbs to soil particles.

Studies have detected it in air and rainwater samples, suggesting that its transport and fate in the atmosphere is linked to airborne particulate matter. The Illinois State Water Survey (ISWS) and the Illinois Sustainable Technology Center (ISTC) have performed limited studies to assess the transport of glyphosate in the atmosphere.

The National Atmospheric Deposition Program (NADP) within ISWS collects rainwater and snowmelt samples at more than 300 locations across North America. Preliminary work performed at ISTC has demonstrated that glyphosate and several of its environmental decomposition products can be readily measured by liquid chromatography tandem mass spectrometry (LCMS) down to 60 ng/L.

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Evaluation of Ammonia Air-Surface Exchange at the Field Scale: Improvement of Soil and Stomatal Emission Potential Parameterizations

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Intensive agriculture typically uses nitrogen-based fertilizers to increase yields for sustaining a growing human population. Agriculture is the main source of atmospheric emissions of ammonia (NH_3), a precursor to particulate matter in the atmosphere. The impact of NH_3 emissions on air quality is of concern in the U.S. due to adverse effects on human health, and terrestrial and aquatic ecosystems. With reductions in nitrogen oxide emissions due to legislation implementation, the importance to NH_3 for particulate matter formation and atmospheric deposition of reactive nitrogen has increased. Emissions of NH_3 from fertilized cropland occur as soon as fertilizer is applied on the farmed surface and emission can last from a few days to several weeks, depending on the properties of the specific fertilizer, plant properties, pedoclimatic conditions, environmental conditions, and agricultural practices. The complex interactions between agronomic and environmental conditions make necessary the use of modeling to study the NH_3 volatilization.

In this study, we implemented in the SURFATM-NH_3 model, which simulates the bi-directional exchanges of NH_3 between the biogenic surface and the atmosphere, a new parameterization of the stomatal and ground layer emission potentials (Γ_s and Γ_g). This operational parameterization enables a dynamic modelling of Γ_s and Γ_g by taking into account the N status of the plant which includes the N input and the atmospheric N deposition.

This new parameterization was evaluated with a dataset comprising NH_3 fluxes measured using the flux-gradient (FG) and relaxed eddy accumulation (REA) methods in a corn canopy fertilized with UAN and urease inhibitor NBPT over a period of approximately 3 months at the Energy Farm at the University of Illinois at Urbana-Champaign, IL, USA. The results showed that the SURFATM- NH_3 model satisfactorily simulates the NH_3 fluxes by implementing the parameterization of Γ_s and Γ_g and by taking into account the effect of the urease inhibitor. The latter need to be more closely examined because it had a considerable effect on the rate and extent of NH_3volatilization.

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N Deposition Effects on Hermes Copper Butterfly (*Lycaena hermes*) Habitat in Southern California

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Atmospheric nitrogen (N) deposition has become a global concern over the past few decades as population sizes have increased. San Diego County, CA, USA, with a high population density, Mediterranean-type climate, and high biodiversity, is an ideal site for an extensive N deposition study. Chronic anthropogenic N deposition is one of the main contributing factors to affect plant species diversity (Vourlitis and Pasquini 2009) and invasive species encroachment (Minnich and Dezzani 1998). It is also the location of the rare endemic Hermes copper butterfly (*Lycaena hermes*), which has received minimal research and remains a mystery to many ecologists. We hypothesized that N deposition will impact Hermes abundance; however, there is limited research on the effects of N deposition on butterfly habitat. Thus, this study aims to determine the effect of increased N on the alterations to plant-insect interactions. These effects are being measured at five sites throughout San Diego County in current or historical Hermes copper habitat. N deposition collectors have been placed under the canopy of spiny redberry shrubs (*Rhamnus crocea*) to accumulate N throughfall at each site. Soil and redberry stem fragments are being used to analyze total N and Carbon (C), water potential, and shrub growth throughout the course of this study. Despite the preliminary nature of our results, we show a number of trends between data groups, such as large differences in soil and tissue N and C between the study sites, suggesting differences in atmospheric N inputs. These variations in soil N availability lead to variations in leaf tissue chemistry, which can ultimately impact the performance of the Hermes copper larvae. Our current data demonstrate some clear trends, but whether these trends remain consistent and interpretable remains to be seen. We anticipate this research will increase our understanding of spatial variation patterns of N deposition in southern California and how that N input might affect the rare Hermes copper butterfly and its host plant, *Rhamnus crocea*. Furthermore, these data are important because they might help us understand why Hermes is in decline and which sites should be prioritized for management.

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Evaluating Variation in Sources of Atmospheric Nitrogen Deposition in the Rocky Mountains using $d^{15}N{-}NO_3^-$ and $d^{15}N{-}NH_4^+$

Leora Nanus[1], Christopher M.B. Lehmann[2] and M. Alisa Mast[3]

Spatial and temporal variation in sources of nitrogen (N) deposition to high-elevation ecosystems in the Rocky Mountains were evaluated using N isotope data for water years 1995-2016. This unique dataset links N in wet deposition and snowpack to emissions sources, and improves understanding of the impacts of anthropogenic activities and environmental policies that mitigate effects of accelerated N cycling. $d^{15}N{-}NO_3^-$ at 50 US Geological Survey Rocky Mountain Snowpack sites ranged from −3.3 ‰ to +6.5 ‰, with a mean value of +1.4 ‰. At 15 National Atmospheric Deposition Program (NADP)/National Trends Network wet deposition sites, summer $d^{15}N{-}NO_3^-$ is significantly lower ranging from −7.6 ‰ to −1.3 ‰ while winter $d^{15}N{-}NO_3^-$ ranges from −2.6 ‰ to +5.5 ‰, with a mean value of +0.7 ‰ during the cool season. Winter NADP wet deposition $d^{15}N{-}NO_3^-$ is lower than snowpack, possibly due to the influence of dry deposition in the snowpack. Spatial trends in wet deposition are similar to Snowpack, with higher NO_3^- concentrations and $d^{15}N{-}NO_3^-$ in the Southern Rockies located near larger anthropogenic N emission sources compared to the Northern Rockies. Wet deposition $d^{15}N{-}NH_4^+$ ranged from −10 ‰ to 0 ‰, with no observed spatial pattern. However, the lowest $d^{15}N{-}NH_4^+$(−9 ‰), and the highest NH_4^+ concentration (35 meq/L) were observed at a Utah site dominated by local agricultural activities, whereas the higher $d^{15}N{-}NH_4^+$ observed in Colorado and Wyoming are likely due to mixed sources, including fossil fuel combustion. These findings show spatial and seasonal variation in N isotope data that reflect differences in sources of anthropogenic N deposition to high-elevation ecosystems and have important implications for environmental policy.

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An Air Quality Portal to Support the Use of Critical Loads of Atmospheric Deposition in National Forest and Grassland Planning

Claire O'Dea[1], Linda Geiser[2], Rich Pouyat[3], Anita Rose[4], and Linda Pardo[5]

Forest Plans provide the basis for management decisions made on national forests and grasslands of the United States. The USDA Forest Service 2012 Planning Rule requires national forest and grassland managers to consider air quality when developing plan components and to treat air resources similar to soil and water resources. This provides a unique opportunity to standardize the way national forests view and manage air quality as a forest resource. By creating an easy-to-use resource to guide managers in considering and treating air quality, we can ensure a nationally consistent methodology which incorporates the best available science and data and eases the burden on the managers. The Air Quality Portal ensures that managers understand the concept of critical loads of air pollution, allowing for appropriate incorporation of critical loads/exposures and target loads/exposures into Forest Plan revisions to meet the intent of the 2012 Planning Rule. The Portal hosts the following documents:

- Decision tree guiding a nationally standardized air quality assessment process to determine exceedances of critical loads of air pollution
- Decision trees guiding monitoring and management decisions based on the results of the air quality assessment
- Detailed protocols/instructions for following assessment process
- Spatial data available for download (and/or potentially for web viewing)
- Sample specialist report(s)
- Briefing papers and other communications tools
- Training tools

The Air Quality Portal, accessible from https://www.srs.fs.usda.gov/airqualityportal/, will be demonstrated live by US Forest Service staff during the poster session of the NADP meeting.

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HANDS-ON CRITICAL LOADS TOOL DEMO: N-CLAS
Effects of Climate, Site and Soil Characteristics on Critical Loads and Exceedance in Forests in the Northeastern U.S.

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

Assessing the impacts of the multiple threats impacting ecosystem health and sustainability over the long term, in particular climate change and nitrogen (N) deposition, remains a critical challenge for resources managers and policy makers. To facilitate such assessments, we developed a GIS-based tool, Nitrogen Critical Loads Assessment by Site (N-CLAS), which calculates critical loads and exceedances for N deposition to forests in the northeastern US. It provides high resolution outputs (maps, graphs, and tables) for multiple areas and accounts for the influence of site, climate, and topographic conditions on 23 key tree species in the region. N-CLAS evaluates the impact of multiple stressors (N deposition and climate change) simultaneously for species of management concern on forest lands in the Northeast and Upper Midwest. In addition to calculating species-specific critical loads, N-CLAS is designed to take into account the impact of site abiotic factors on the response of trees to N deposition. The abiotic modifying factors include, precipitation, temperature (e.g., January T, July T, May-September T), and soil characteristics. This tool is designed N-CLAS facilitates assessment of risk to forest ecosystems for resource managers and policy makers.

In this hands-on demo session, we will demonstrate how to use the tool, the types of outputs it produces, and the ways that it can be utilized to assess extent and magnitude of risk to forest ecosystems and to evaluate the susceptibility of individual tree species.

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Effects of Climate, Site and Soil Characteristics on Critical Loads and Exceedance in Forests in the Northeastern U.S.

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

Assessing the impacts of the multiple threats impacting ecosystem health and sustainability over the long term, in particular climate change and nitrogen (N) deposition, remains a critical challenge for resources managers and policy makers. To facilitate such assessments, we used a GIS-based tool, Nitrogen Critical Loads Assessment by Site (N-CLAS), to evaluate the impact of multiple stressors (N deposition and climate change) simultaneously for species of management concern on forest lands in the Northeast and Upper Midwest. In addition to calculating species-specific critical loads, N-CLAS is designed to take into account the impact of site abiotic factors on the response of trees to N deposition. The abiotic modifying factors include, precipitation, temperature (e.g., January T, July T, May-September T), and soil characteristics. We conducted our analysis for the full region and at the Ecoregion levels 2 and 3. Application of N-CLAS across the northeastern U.S. allows us to evaluate which areas and tree species are most susceptible to impacts from N deposition. In this analysis, we determined the critical load and exceedance for individual tree species and all the species present. We also evaluated the extent and magnitude of the CL exceedance and how that would change under future deposition scenarios. N-CLAS facilitates analysis of the extent of the area impacted by N deposition which provides resource managers with a simple way to incorporate the current state-of-the-science knowledge into their planning and management decisions.

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Atmospheric Elemental Carbon Deposition to Oak Trees and Litterfall Flux to Soil in an Urban Area

Jenna Rindy[1], Alexandra G. Ponette-González[2], Tate E. Barrett[3] and Brett W. Luce[4]

Elemental Carbon (EC), a product of incomplete combustion of fossil fuels and biomass, contributes to climate warming and poor air quality. In urban areas, diesel fuel trucks are the main source of EC emissions from mobile sources. After emission, EC is deposited to receptor surfaces via two main pathways: precipitation (wet deposition) and directly as particles (dry deposition). Urban trees may play an important role in removing EC from the atmosphere by intercepting and delivering it directly to the soil. The goal of this research is to quantify the magnitude of EC retention on leaf surfaces (leaf EC) and EC fluxes to soil via leaf litterfall in the City of Denton, Texas. Denton is a rapidly growing urban area north of the Dallas-Fort Worth metropolitan Area. We are using a foliar extraction technique to determine EC retention on leaf surfaces. Foliar samples are being collected monthly, from April to November, from co-located *Quercus stellata* (post oak, *n* = 10) and *Quercus virginiana* (live oak, *n* = 10) trees. Samples are rinsed with water and chloroform in a two-step process to determine surface-deposited EC and EC retained in leaf waxes. A Sunset EC/OC carbon analyzer will be utilized to analyze EC content of extracts filtered onto quartz-fiber filters. For one year, leaf litter is being collected bi-weekly under 35 trees (20 post oak, 15 live oak), and oven dried to determine dry weight. EC retained by tree canopies will be calculated by multiplying leaf EC by canopy leaf area index, while EC flux to soil will be estimated by multiplying in-wax EC by leaf litterfall mass. Here, preliminary results of EC retention on leaf surfaces, as well as EC flux to soil for spring and summer 2017 are presented. Results of this study will assess urban tree's ability to filter air pollution and mitigate climate change.

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CASTNET Ozone Monitoring Program

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

The Clean Air Status and Trends Network (CASTNET) is a long-term monitoring network designed to measure acidic pollutants and ambient ozone (O_3) concentrations in rural areas in the United States and Canada. CASTNET is managed collaboratively by the Environmental Protection Agency – Clean Air Markets Division (EPA), the National Park Service – Air Resources Division (NPS), and the Bureau of Land Management – Wyoming State Office (BLM-WSO). In addition to EPA, NPS, and BLM-WSO, numerous other participants provide site operator support and grant land access including North American tribes, other federal agencies, States, private land owners, and universities.

Eighty-two CASTNET sites report hourly O_3 concentrations. The data provide accountability for EPA's regional Nox emission reduction programs (i.e. Nox SIP Call, Cross State Air Pollution Rule, and Cross State Air Pollution Rule Update) and exposure effects on vegetation. The National Park Service uses CASTNET O_3 data to develop strategies for improving visibility and protecting resources within park boundaries. Additionally, eighty of the O_3 monitors at CASTNET sites meet the requirements of Title 40 of the Code of Federal Regulations (CFR) Part 58 and are used to determine compliance with the O_3National Ambient Air Quality Standard (NAAQS). Populations located in areas that exceed the primary NAAQS are more susceptible to adverse health effects. CASTNET provides a unique dataset to rural populations where state-operated O_3 monitors are not required.

Each CASTNET monitor measures ambient O_3 concentrations for the entire year. CASTNET O_3 data are submitted to the AIRNow Tech website for near-real time reporting (www.airnowtech.org) and to EPA's Air Quality System (AQS) database (https://aqs.epa.gov/aqs). Annual performance evaluations (PE) and results from the National Performance Audit Program (NPAP) are also submitted to AQS routinely.

Preliminary 2014-2016 3-year average of the fourth highest daily maximum rolling 8-hour averages calculated using the 2015 ozone NAAQS indicate that four CASTNET sites exceed the 70 ppb O_3 NAAQS including Joshua Tree National Park, CA; Sequoia National Park, CA; Yosemite National Park, CA; and Washington Crossing, NJ.

Ozone data and additional information about the CASTNET monitoring program can be found on the CASTNET webpage at https://www.epa.gov/castnet.

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Characterization of Reduced Nitrogen at IMPROVE and CSN Monitoring Sites in the Southeastern United States

Christopher Rogers[1], John Walker[2], Rich Scheffe[3], Kevin Mishoe[4], Doris Chen[5], Katherine Barry[6], Melissa Puchalski[7], Bret Schichtel[8] and Joann Rice[9]

The Interagency Monitoring of Protected Visual Environments (IMPROVE) and Chemical Speciation (CSN) networks have provided two decades of routine particulate matter (PM) speciation data that support regional haze and PM NAAQS programs. As shown by the NADP wet deposition record over the same period, the chemical composition of the ambient atmosphere has changed markedly from one dominated by nitrate, sulfate, and carbonaceous aerosols, and their associated precursor gases to an atmospheric mixture that includes a significant amount of reduced inorganic nitrogen – particulate ammonium (NH_4^+) and its precursor gas, ammonia (NH_3). The magnitude of this change is reflected by a nationwide shift in the atmospheric composition from one dominated by inorganic oxidized compounds, to one where reduced inorganic nitrogen species ($NH_x = NH_3 + NH_4^+$) now have similar or greater contributions to the total nitrogen budget.

To address this change, it becomes necessary to characterize reduced nitrogen emission sources and atmospheric composition. Previous studies conducted primarily in the western United States have examined the possibility of using acid-impregnated filters in the IMPROVE system to measure NH_x. Results were considered successful leading to a current study using acid-impregnated filters in both the IMPROVE and CSN systems to conduct similar measurements in the southeastern United States.

The study is occurring from late May through late November 2017 at Duke Forest, NC (near Research Triangle Park) and Gainesville, FL. Both sites are running CSN, IMPROVE, and URG annular denuder systems as the reference method to measure NH_x. In addition, both sites include NH_4^+ and NH_3 measurements from the CASTNET filter pack and NADP/AMoN, respectively. The Duke Forest site also has a Monitor for Aerosols and Gases in Ambient Air (MARGA) collecting hourly measurements of NH_3 and NH_4^+. Here, results from the Duke Forest and Gainesville sites are compared to determine the feasibility of adding an acid-impregnated filter to capture NH_x at a subset of the IMPROVE and CSN long-term measurement stations.

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The Atmospheric Chemistry and Canopy Exchange Simulation System for Ammonia (ACCESS-NH3): Formulation and Application to a Corn Canopy

Rick Saylor[1], LaToya Myles[2], Nebila Lichiheb[3], Mark Heuer[4], Andrew Nelson[5], Sotiria Koloutsou-Vakakis[6]and Mark Rood[7]

As nitrogen oxide and sulfur dioxide emissions decrease in the U. S. as a result of implemented air quality regulations, agricultural emissions of ammonia (NH_3) are being recognized as playing an increasingly important role in fine particle ($PM_{2.5}$) formation. If regulations on agricultural emissions are implemented in the future, it will be necessary to have reliable models of NH_3 bi-directional exchange over a variety of crop types to help formulate effective control or mitigation strategies. The Atmospheric Chemistry and Canopy Exchange Simulation System for Ammonia (ACCESS-NH3) is a multilayer, single column model that simulates the bi-directional transport and exchange of ammonia throughout the soil-plant-atmosphere continuum. In this presentation, the ACCESS-NH3 modeling system is described and results from its application to a corn (Zea mays) canopy are presented. NH_3 concentration and flux measurements, along with micrometeorological and environmental observations, were made within and above a Zea mays canopy at the University of Illinois Energy Biosciences Institute Energy Farm in Urbana, IL, during the entire growing season of 2014. ACCESS-NH3 has been applied to the data obtained during this field experiment to evaluate the model and to assess how NH_3 interacts with the Zea mays canopy and how these interactions vary over the growing season and as a function of environmental conditions. Results from the evaluations and simulations will be presented.

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Long-term Trends in Atmospheric Sulfur and Nitrogen Species across the United States: 30 years of Clean Air Status Network (CASTNET) Operations

David Schmeltz[1], Melissa Puchalski[2], Gary Lear[3], Greg Beachley[4], Kemp Howell[5], Taylor Macy[6], Chris Rogers[7], Tim Sharac[8] and Marcus Stewart[9]

The Clean Air Status and Trends Network (CASTNET) and the National Atmospheric Deposition Program (NADP) offer a robust capability to investigate long-term trends in atmospheric concentrations and deposition of sulfur and nitrogen species in rural areas of the U.S. The U.S. EPA, National Park Service, and the Bureau of Land Management (Wyoming State Office) manage the CASTNET program and network operations at 90+ sites located throughout the contiguous US, Alaska, and Canada. For nearly three decades, CASTNET has produced data of proven quality following consistent methods required for long-term trends analysis. Observational data from CASTNET (and NADP) are used commonly to assess the effectiveness of emission control policies, to evaluate and develop air quality models, and are important inputs to critical load assessments and ecosystem studies. CASTNET is recognized as a dynamic and resilient program that has evolved to respond to changing agency objectives and emerging issues while still maintaining a consistent set of measurements (SO_2, HNO_3, SO_4, NO_3, NH_4, base cations, CL, and O_3) over time in the face of static or declining federal budgets. CASTNET complements measurements from co-located or nearby air quality monitoring network sites (i.e. NCore, Chemical Speciation Network, Interagency Monitoring of Protected Visual Environments). Further, the CASTNET platform has facilitated new deposition and effects research and methods development geared toward reducing uncertainties in the nitrogen budget. Here we present results from CASTNET, featuring regional long-term trends (1990-2016) in atmospheric concentrations and estimates of dry deposition of key sulfur and nitrogen species. We also look at how the network has adapted to advance deposition research, reduce spatial gaps in remote areas, and build or expand upon existing partnerships to meet the evolving needs of the policy and scientific communities. Finally, we discuss the challenges the network will face in the next 5-years and plans for minimizing the impacts of those challenges.

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Mobile Measurements of Atmospheric Ammonia in Northeastern Colorado

Yixing Shao[1], Jeffrey L. Collett, Jr.[2] and Katherine B. Benedict[3]

The spatial and temporal variability of ammonia is not well characterized in regions like northeastern Colorado where there are large agricultural sources adjacent to urban and remote areas. Northeastern Colorado is of interest since it is home to Rocky Mountain National Park (RMNP), a protected area experiencing the effects of increased nitrogen deposition. To protect the park from increasing nitrogen deposition it is crucial to understand the degree to which the urban and agricultural sources are impacting RMNP, as well as how meteorological conditions are influencing the ammonia concentrations and nitrogen deposition in the park. Mobile measurements of ammonia were made in June 2016 to examine the spatial variability of ammonia at high-time resolution. These data, together with modeling results from the Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT), will be used to investigate the transport of ammonia across the region. From previous observations it is unclear whether distinct plumes of ammonia are being transported over large distances or whether regional ammonia concentrations are relatively homogeneous. The combination of these measurements and modeling results will provide a clearer picture of how ammonia-rich air parcels in the eastern plains of Colorado are transported and contribute to nitrogen deposition in the park.

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Deposition of Atmospheric Mercury to the Lulin Atmospheric Background Station (LABS) in Taiwan in 2009-2016

Guey-Rong Sheu[1], Nguyen Ly Sy Phu[2], Da-Wei Lin[3], Leiming Zhang[4] and Neng-Huei Lin[5]

Although East Asia is the major anthropogenic mercury (Hg) emission source region, studies concerning atmospheric Hg deposition in its downwind region are still limited. Taiwan is considered downwind of the East Asian continent in fall, winter and spring because of regional monsoon activity. Monitoring of various atmospheric Hg species, including gaseous elemental Hg (GEM), gaseous oxidized Hg (GOM) and particle-bound Hg (PBM), began since April 2006, whereas collection of weekly rainwater samples for total Hg analyses began since early 2009, at the Lulin Atmospheric Background Station (LABS; 120.87ºE, 23.47ºN, 2862 m a.s.l.), a tropical mountain-top site in central Taiwan. Here we reported the wet and dry deposition of atmospheric Hg to the LABS between 2009 and 2016. Dry deposition of speciated Hg was estimated using bidirectional air-surface resistance model. Amounts of annual rainfall ranged from 2160 to 4991 mm and the volume-weighted mean concentrations of rainwater Hg ranged from 5.04 to 13.08 ng L^{-1}. Annual wet Hg deposition fluxes ranged between 10.89 and 46.05 µg m^{-2}, with a grand average of 27.3 µg m^{-2} yr^{-1}. Wet Hg deposition fluxes were higher in summer as a result of higher rainfall and rainwater Hg concentrations. Weekly wet deposition fluxes and rain depths were highly correlated ($R^2 = 0.654$, $p < 0.01$). As there is no anthropogenic Hg emission source around the LABS, the high summertime rainwater Hg concentration hints at the importance of Hg^0 oxidation and/or scavenging of upper-altitude Hg(II) by deep convection. Annual dry deposition fluxes ranged from 51.79 to 70.15 µg m^{-2}, with a grand average of 60.8 µg m^{-2} yr^{-1}. On average, the annual dry deposition flux was 2.2 times that of wet flux. Nighttime GOM dry deposition flux (8.09±1.96 µg m^{-2} yr^{-1}) was higher than that of daytime (5.21±1.58 µg m^{-2} yr^{-1}) because of higher GOM concentration and wind speed at night. Due to the high percentage of forest canopy coverage around the LABS, average annual GEM dry deposition flux (47.2 µg m^{-2}) was significantly higher than GOM (13.31 µg m^{-2}) and PBM (0.21 µg m^{-2}). Results of this research indicate that wet and dry Hg deposition fluxes to the tropical mountain site are significantly higher than values reported from sites in temperate region.

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AMoN Site Characterization Study: Phase I Field Measurements

John Walker[1], Kevin Mishoe[2], Christopher Rogers[3], Zhiyong Wu[4], Melissa Puchalski[5], Donna Schwede[6], Kim Hutchison[7], Wayne Robarge[8] and Ralph Baumgardner[9]

Reduced inorganic nitrogen ($NH_3 + NH_4^+$) is an increasingly important contributor to the total nitrogen deposition budget, yet the bi-directional nature of NH_3 air-surface exchange makes incorporation of NH_3 measurements into dry deposition schemes in field-scale and regional chemical transport models (i.e. CMAQ) difficult. The purpose of this study is to develop a methodology for providing NADP with modeled NH_3 fluxes using bi-weekly AMoN concentrations. NH_3 fluxes derived from site specific NH_3 measurements (AMoN) and surface parameterizations (i.e., compensation points) will provide "best" estimates of NH_3 deposition for developing ecosystem specific deposition budgets, assessing sub-grid variability of fluxes within CMAQ, and characterizing the impact of bias correcting CMAQ NH_3 concentrations on NH_3 fluxes. This effort will therefore improve the total nitrogen deposition estimates provided by TDEP, which does not currently use the AMoN NH_3 concentrations for deposition estimates.

The first phase of the project will focus on measurements while the 2nd phase will focus on evaluation of the bi-directional air-surface exchange model. During Phase I, a database of soil and vegetation chemistry, micrometeorology, and surface physical characteristics will be developed for 3 pilot sites: Chiricahua National Monument, AZ (desert); Bondville, IL (agricultural); and Duke Forest, NC (hardwood forest). These sites were selected based on available data (AMoN, CASTNET, and NADP/NTN), and differences in land-use type, vegetation and soil types, and average ambient NH_3 concentrations. Soil, live vegetation, and litter will be collected and analyzed for NH_4^+ and pH to develop seasonal estimates of surface NH_3 emission potentials (Γ) from which compensation points will be derived. Biogeochemistry will be combined with on-site meteorology and surface characteristics will be used to calculate net and component fluxes (i.e., foliage versus ground) using a 2-layer bi-directional flux model. Measurements will be used to assess model sensitivities to biogeochemical and meteorological inputs to develop a model suitable for implementation across the entire AMoN network.

Field measurements began in the summer of 2017 and will continue through spring 2018. Here we describe the field and laboratory measurement methods that have been designed to capture a robust biogeochemical dataset for the 3 AMoN pilot sites. Aspects of model development and evaluation will also be discussed.

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Testing Coastal Lichen and Moss Species as a Bioindicator of Atmospheric Total Mercury and Monomethylmercury in Santa Cruz County, CA

Belle Zheng[1], Wendy Lin[2], Peter Weiss-Penzias[3], Ken Kellman[4], Alfred Freeberg[5] and Brian Young[6]

Lichen are unique terrestrial organisms that form stable mutualistic associations between fungi, algae and cyanobacteria.. They have also been used as indicators of healthy air as they are able to accumulate airborne pollutants such as heavy metals like mercury in their thalli (vegetative tissue). A previous study done in the Canadian High Arctic found that lichen had median monomethylmercury (MMHg) and median total mercury (THg) concentrations that were two orders higher of magnitude than the soils underlying them. Intrigued by these data, we decided to test the concentrations of MMHg and THg in lichen and moss in Santa Cruz, CA. The main purpose of the study is to find out whether lichens and mosses can be used as bioindicators of environmental mercury, especially the effects of coastal fog. Various lichen and moss species were collected in Santa Cruz County, then freeze-dried and homogenized, and then analyzed for MMHg and THg concentrations. Lichen and moss THg concentrations ranged from 31.9 to 400.4 ng g-1, with an average of 178.9±111 ng g-1. Lichen and moss MMHg concentrations ranged from 3.86 ng g-1 to 73.3 ng g-1, with an average of 30.3±37.8 ng g-1. In a similar study the median THg and median MMHg were found at 66.8 ng g-1 and 4.27 ng g-1 respectively. From our preliminary data, we are optimistic that lichen and moss are good indicators of airborne mercury concentrations. We will continue this idea by sampling along a coastal-inland transect (fog frequency gradient) at the end of the fog season. Our study may be able to provide insight on how MMHg and THg enter the coastal food chain through fog water deposition.

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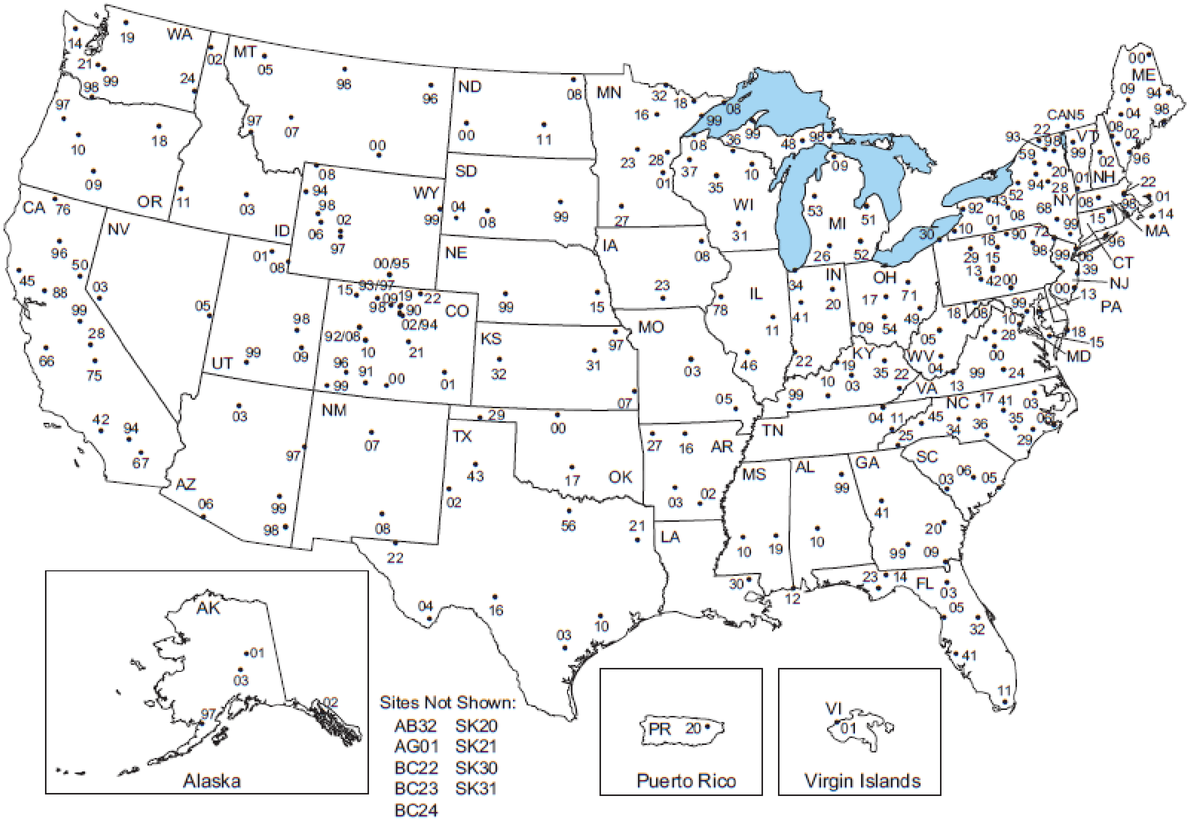
NTN Map and Site Listings

National Atmospheric Deposition Program
National Trends Network



National Atmospheric Deposition Program/National Trends Network Sites

July 31, 2017

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

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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Colorado				
CO00	Alamosa		US Geological Survey	04/80
CO01	Las Animas Fish Hatchery		US Geological Survey	10/83
CO02	Niwot Saddle		NSF-Institute of Arctic & Alpine Research/University of CO	06/84
CO06	CAMP		City and County of Denver	01/17
CO08	Four Mile Park		US Environmental Protection Agency-CAM	12/87
CO09	Kawaneechee Meadow		US Bureau of Land Management/National Park Service-ARD	07/12
CO10	Gothic	AMoN	US Environmental Protection Agency-CAM	02/99
CO11	Arvada Gardens		US Geological Survey	12/16
CO15	Sand Spring		US Bureau of Land Management	03/79
CO19	Rocky Mountain NP - Beaver Meadows		National Park Service - Air Resources Division	05/80
CO21	Manitou		USDA Forest Service	10/78
CO22	Pawnee		National Park Service - Air Resources Division	05/79
CO84	Betasso		US Geological Survey	05/17
CO85	Boulder		CO DPHE	01/17
CO86	Rocky Flats NWR		US Fish & Wildlife Service - Air Quality Branch	01/17

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
CO87	National Jewish Hospital		CO DPHE	01/17
CO90	Niwot Ridge-Southeast		NSF-Institute of Arctic & Alpine Research/University of CO	01/06
CO91	Wolf Creek Pass		USDA Forest Service	05/92
CO92	Sunlight Peak		US Environmental Protection Agency-CAM	01/88
CO93	Buffalo Pass - Dry Lake		USDA Forest Service	10/86
CO94	Sugarloaf		US Environmental Protection Agency-CAM	11/86
CO96	Molas Pass	MDN	USDA Forest Service	07/86
CO97	Buffalo Pass - Summit Lake	MDN	USDA Forest Service	02/84
CO98	Rocky Mountain NP - Loch Vale	AMoN	USGS/Colorado State University	08/83
CO99	Mesa Verde NP - Chapin Mesa	MDN	US Geological Survey	04/81
Connecticut				
CT15	Abington	AMoN	US Environmental Protection Agency-CAM	01/99
Florida				
FL03	Bradford Forest		US Environmental Protection Agency-CAM	10/78
FL05	Chassahowitzka NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	08/96
FL11	Everglades NP - Research Center	MDN/AMoN	National Park Service - Air Resources Division	06/80

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
FL14	Quincy		US Geological Survey	03/84
FL23	Sumatra	AMoN	US Environmental Protection Agency-CAM	01/99
FL32	Orlando		Orange County Government	12/05
FL41	Verna Well Field		US Geological Survey	08/83
Georgia				
GA09	Okefenokee NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	06/97
GA20	Bellville		US Environmental Protection Agency-CAM	04/83
GA41	Georgia Station		Univeristy of Georgia	10/78
GA99	Chula		US Geological Survey	02/94
Idaho				
ID02	Priest River Experimental Forest		USDA Forest Service	12/02
ID03	Craters of the Moon NM	AMoN	National Park Service - Air Resources Division	08/80
ID11	Reynolds Creek		US Geological Survey	11/83

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

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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Maryland				
MD08	Piney Reservoir	MDN/AMNet/ AMoN	Maryland Department of Natural Resources	06/04
MD13	Wye		SAES-University of Maryland	03/83
MD15	Smith Island		NOAA-Air Resources Lab	06/04
MD18	Assateague Island NS - Woodcock		Maryland Department of Natural Resources	09/00
MD99	Beltsville	MDN/AMNet AMoN	Maryland Department of Natural Resources	06/04
Massachusetts				
MA01	North Atlantic Coastal Lab	MDN	National Park Service - Air Resources Division	12/81
MA08	Quabbin Reservoir		Northeast States for Coordinated Air Use Management	03/82
MA14	Nantucket		Nantucket Land Council	03/14
MA22	Boston University		Boston University - Department of Biology	06/15
MA98	Arnold Arboretum		Arnold Arboretum of Harvard University	02/16
Michigan				
MI09	Douglas Lake	MDN	SAES-Michigan State University	07/79
MI26	Kellogg Biological Station	MDN	SAES-Michigan State University	06/79
MI48	Seney NWR - Headquarters	MDN	US Fish & Wildlife Service - Air Quality Branch	11/00
MI51	Unionville	AMoN	US Environmental Protection Agency-CAM	01/99
MI52	Ann Arbor	MDN/AMoN	US Environmental Protection Agency-CAM	01/99
MI53	Wellston		USDA Forest Service	10/78
MI98	Raco		US Environmental Protection Agency-CAM	05/84
MI99	Chassell		USDA Forest Service	02/83

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

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

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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
North Carolina				
NC03	Lewiston		North Carolina State University/US Geological Survey	10/78
NC06	Beaufort	AMoN	US Environmental Protection Agency-CAM	01/99
NC25	Coweeta	AMoN	USDA Forest Service	07/78
NC29	Hofmann Forest		US Geological Survey	07/02
NC34	Piedmont Research Station		North Carolina State University	10/78
NC35	Clinton Crops Research Station	AMoN	North Carolina State University	10/78
NC36	Jordan Creek		US Geological Survey	10/83
NC41	Finley Farms		North Carolina State University	10/78
NC45	Mount Mitchell		US Environmental Protection Agency-CAM	11/85
North Dakota				
ND00	Theodore Roosevelt NP-Painted Canyon		National Park Service-Air Resources Division	01/01
ND08	Icelandic State Park		US Geological Survey	10/83
ND11	Woodworth		US Geological Survey	11/83
Ohio				
OH09	Oxford	AMoN	US Geological Survey	08/84
OH17	Delaware		USDA Forest Service	10/78
OH49	Caldwell		US Geological Survey	09/78
OH54	Deer Creek State Park	AMoN	US Environmental Protection Agency-CAM	01/99
OH71	Wooster		US Geological Survey	09/78

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

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

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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
VA99	Natural Bridge Station		USDA Forest Service - Air Program	07/02
Washington				
WA14	Olympic NP - Hoh Ranger Station		National Park Service - Air Resources Division	05/80
WA19	North Cascades NP-Marblemount Ranger Stn		US Geological Survey	02/84
WA21	La Grande		US Environmental Protection Agency-CAM	04/84
WA24	Palouse Conservation Farm		US Geological Survey	08/85
WA98	Columbia River Gorge		USDA Forest Service - Pacific Northwest Region	05/02
WA99	Mount Rainier NP - Tahoma Woods	AMoN	National Park Service - Air Resources Division	10/99
West Virginia				
WV04	Babcock State Park		US Geological Survey	09/83
WV05	Cedar Creek State Park	AMoN	US Environmental Protection Agency-CAM	01/99
WV18	Parsons	AMoN	USDA Forest Service	07/78
Wisconsin				
WI08	Brule River	MDN	Wisconsin Department of Natural Resources	04/14
WI10	Potawatomi	MDN	Forest County Potawatomi Community	06/05
WI31	Devil's Lake	MDN	Wisconsin Department of Natural Resources	01/14
WI35	Perkinstown	AMoN	US Environmental Protection Agency-CAM	01/99
WI36	Trout Lake	MDN	Wisconsin Department of Natural Resources	01/80
WI37	Spooner		USDA Forest Service	06/80

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wyoming				
WY00	Snowy Range		USDA Forest Service	04/86
WY02	Sinks Canyon		Bureau of Land Management	08/84
WY06	Pinedale	AMoN	Bureau of Land Management	01/82
WY08	Yellowstone NP - Tower Falls	MDN	National Park Service - Air Resources Division	06/80
WY94	Grand Tetons National Park	AMoN	State of Wyoming DEQ	09/11
WY95	Brooklyn Lake	AMoN	USDA Forest Service	09/92
WY97	South Pass City		USDA Forest Service	04/85
WY98	Gypsum Creek		USDA Forest Service/Bridger Teton NF	12/84
WY99	Newcastle		Bureau of Land Management	08/81
Canada				
AB32	Fort Mackay		Wood Buffalo Environmental Association	09/16
BC22	Haul Road Station		Rio Tinto	09/12
BC23	Lakelse Lake		Rio Tinto	03/13
BC24	Port Edward		Prince Rupert Port Authority	01/14
CAN5	Frelighsburg		US Geological Survey	10/01
SK20	Cactus Lake		Saskatchewan Ministry of Environment	02/12
SK21	Hudson Bay		Saskatchewan Ministry of Environment	04/12
SK30	Weyburn		Saskatchewan Ministry of Environment	06/16
SK31	Fox Valley		Saskatchewan Ministry of Environment	06/16

AIRMoN Map and Site Listings

National Atmospheric Deposition Program

Atmospheric Integrated Research Monitoring Network

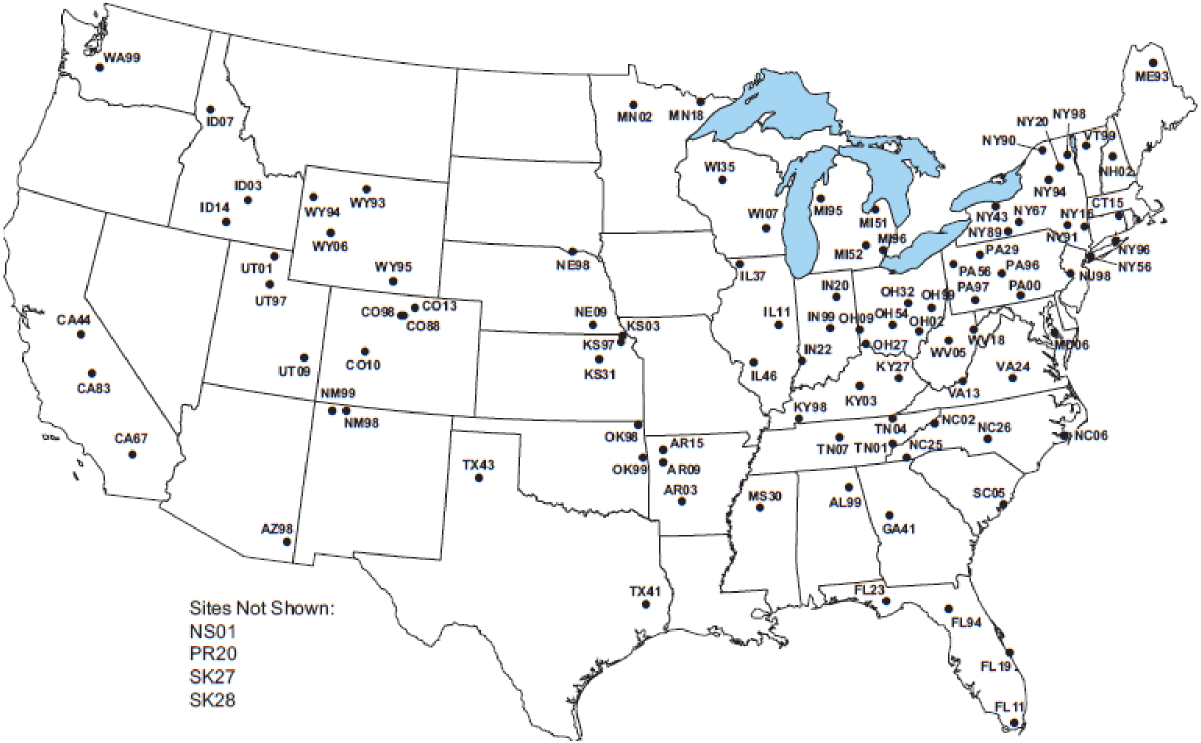
National Atmospheric Deposition Program/Atmospheric Integrated Research Monitoring Network Sites

July 31, 2017

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

AMoN Map and Site Listings

National Atmospheric Deposition Program
Ammonia Monitoring Network



National Atmospheric Deposition Program/Ammonia Monitoring Network Sites

July 31, 2017

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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Florida				
FL11	Everglades NP - Research Center	NTN/MDN	National Park Service - Air Resources Division	03/11
FL19	Indian River		US Environmental Protection Agency - CAM	04/11
FL23	Sumatra	NTN	US Environmental Protection Agency - CAM	01/15
FL94	Gainesville		US Environmental Protection Agency - CAM	05/17
Georgia				
GA41	Georgia Station	NTN	US Environmental Protection Agency - CAM	06/11
Idaho				
ID03	Craters of the Moon NM	NTN	National Park Service - Air Resources Division	06/10
ID07	Nez Perce		US Environmental Protection Agency - CAM	12/15
Illinois				
IL11	Bondville	AIRMoN/MDN/ NTN	US Environmental Protection Agency - CAM	10/07
IL37	Stockton		US Environmental Protection Agency - CAM	04/11
IL46	Alhambra	NTN	US Environmental Protection Agency - CAM	03/11
Indiana				
IN20	Roush Lake	NTN	US Environmental Protection Agency - CAM	01/15
IN22	SW Purdue Ag Center	MDN	US Environmental Protection Agency - CAM	01/15
IN99	Indianapolis		US Environmental Protection Agency - CAM	10/07

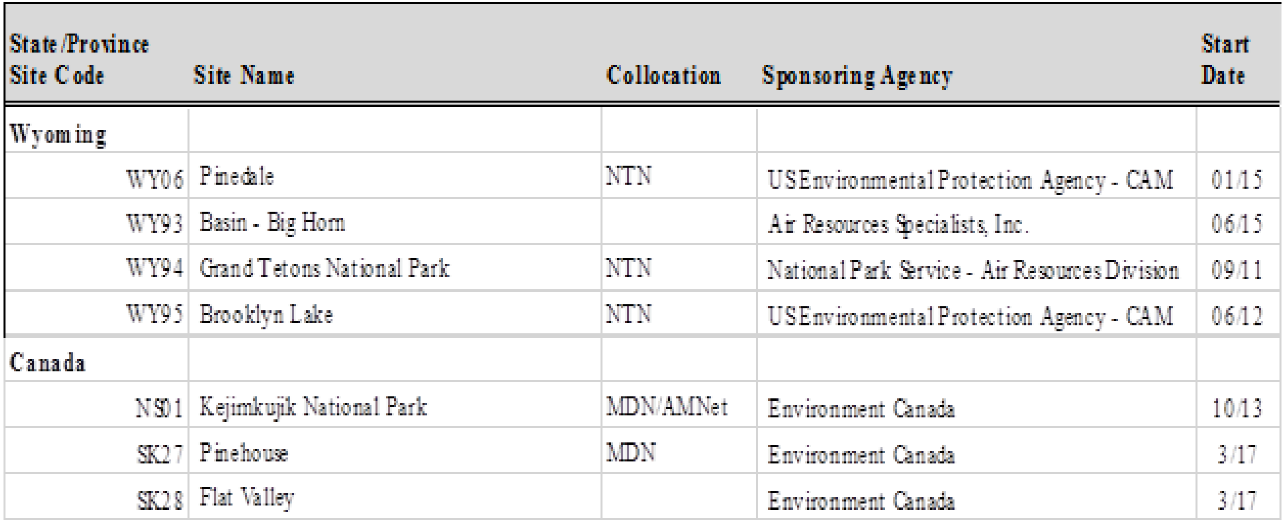
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Kansas				
KS03	Reserve	MDN	Sac and Fox Nation of Missouri	10/11
KS31	Konza Prairie	NTN	US Environmental Protection Agency - CAM	03/11
KS97	Kickapoo Tribe - Powhattan	NTN	US Environmental Protection Agency - CAM	01/15
Kentucky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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Minnesota				
MN02	Red Lake		US Environmental Protection Agency - CAM	01/15
MN18	Fernberg	NTN/MDN	US Environmental Protection Agency - CAM	10/07
Mississippi				
MS30	Coffeeville	NTN	US Environmental Protection Agency - CAM	01/15
Nebraska				
NE09	Homestead		National Park Service - Air Resources Division	07/16
NE98	Santee	MDN	US Environmental Protection Agency - CAM	04/11
New Hampshire				
NH02	Hubbard Brook	NTN	US Environmental Protection Agency - CAM	06/12
New Jersey				
NJ98	Washington Crossing CASTNET		US Environmental Protection Agency - CAM	03/11
New Mexico				
NM98	Navajo Lake		US Environmental Protection Agency - CAM	01/08
NM99	Farmington		US Environmental Protection Agency - CAM	01/08
New York				
NY16	Cary Institute		Cary Institute Of Ecosystem Studies	10/09
NY20	Huntington Wildlife	MDN/AMNet/ NTN	US Environmental Protection Agency - CAM	06/12
NY43	Rochester	MDN/AMNet/ NTN	NYSERDA	06/16
NY56	Queens College		NYSERDA	06/16
NY67	Ithaca	AIRMoN	US Environmental Protection Agency - CAM	10/07

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

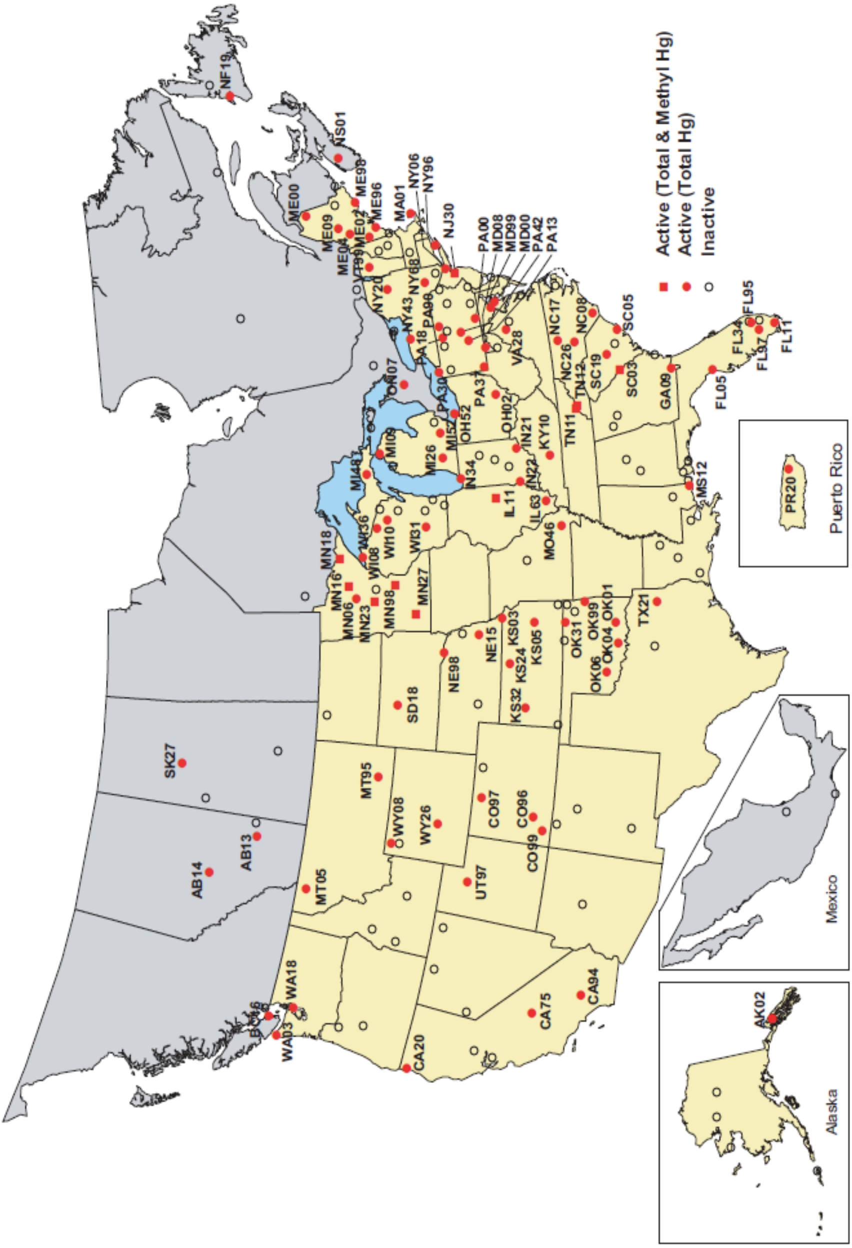
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Pennsylvania				
PA00	Arendtsville	NTN/MDN	US Environmental Protection Agency - CAM	10/09
PA29	Kane Experimental Forest	NTN/MDN	US Environmental Protection Agency - CAM	03/11
PA56	M.K. Goddard		US Environmental Protection Agency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

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



State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wyoming				
WY06	Pinedale	NTN	US Environmental Protection Agency - CAM	01/15
WY93	Basin - Big Horn		Air Resources Specialists, Inc.	06/15
WY94	Grand Tetons National Park	NTN	National Park Service - Air Resources Division	09/11
WY95	Brooklyn Lake	NTN	US Environmental Protection Agency - CAM	06/12
Canada				
NS01	Kejimkujik National Park	MDN/AMNet	Environment Canada	10/13
SK27	Pinehouse	MDN	Environment Canada	3/17
SK28	Flat Valley		Environment Canada	3/17

MDN Map and Site Listings


■ Active (Total & Methyl Hg)
● Active (Total Hg)
○ Inactive
NF19
NS01
ME00
ME98
ME96
ME09
ME02
ME04
VT99
MA01
NY06
NY96
NJ30
PA00
MD08
MD99
MD00
PA42
PA13
NY20
NY43
NY68
PA98
PA18
ON07
PA30
PA37
VA28
NC17
NC08
SC05
NC26
TN12
SC19
SC03
GA09
FL34
FL95
FL97
FL11
FL05
MI09
MI52
OH52
OH02
IN21
KY10
TN11
MI26
IN34
IN22
IL11
IL63
MO46
MS12
MI48
WI36
WI10
WI08
WI31
MN18
MN16
MN06
MN23
MN98
MN27
NE15
KS03
KS05
KS24
KS32
NE98
SD18
OK99
OK01
OK31
OK04
OK06
TX21
MT95
WY08
WY26
CO97
CO96
CO99
UT97
MT05
SK27
AB13
AB14
WA18
BC16
WA03
CA20
CA75
CA94
PR20
Puerto Rico
Mexico
AK02
Alaska

National Atmospheric Deposition Program/Mercury Deposition Network Sites

July 31, 2017

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alaska				
AK02	Juneau	NTN	National Park Service - Air Resources Division	12/16
AK06	Gates of the Arctic NP - Bettles	NTN	US Bureau of Land Management	11/08
AK98	Kodiak		Kodiak Island Burough	
California				
CA20	Yurok Tribe-Requa		Electric Power Research Institute	08/06
CA75	Sequoia NP-Giant Forest	NTN	National Park Service - Air Resources Division	07/03
CA94	Converse Flats	NTN	USDA Forest Service	04/06
Colorado				
CO96	Molas Pass	NTN	US Bureau of Land Management	06/09
CO97	Buffalo Pass - Summit Lake	NTN	USDA Forest Service	09/98
CO99	Mesa Verde NP-Chapin Mesa	NTN	National Park Service - Air Resources Division	12/01

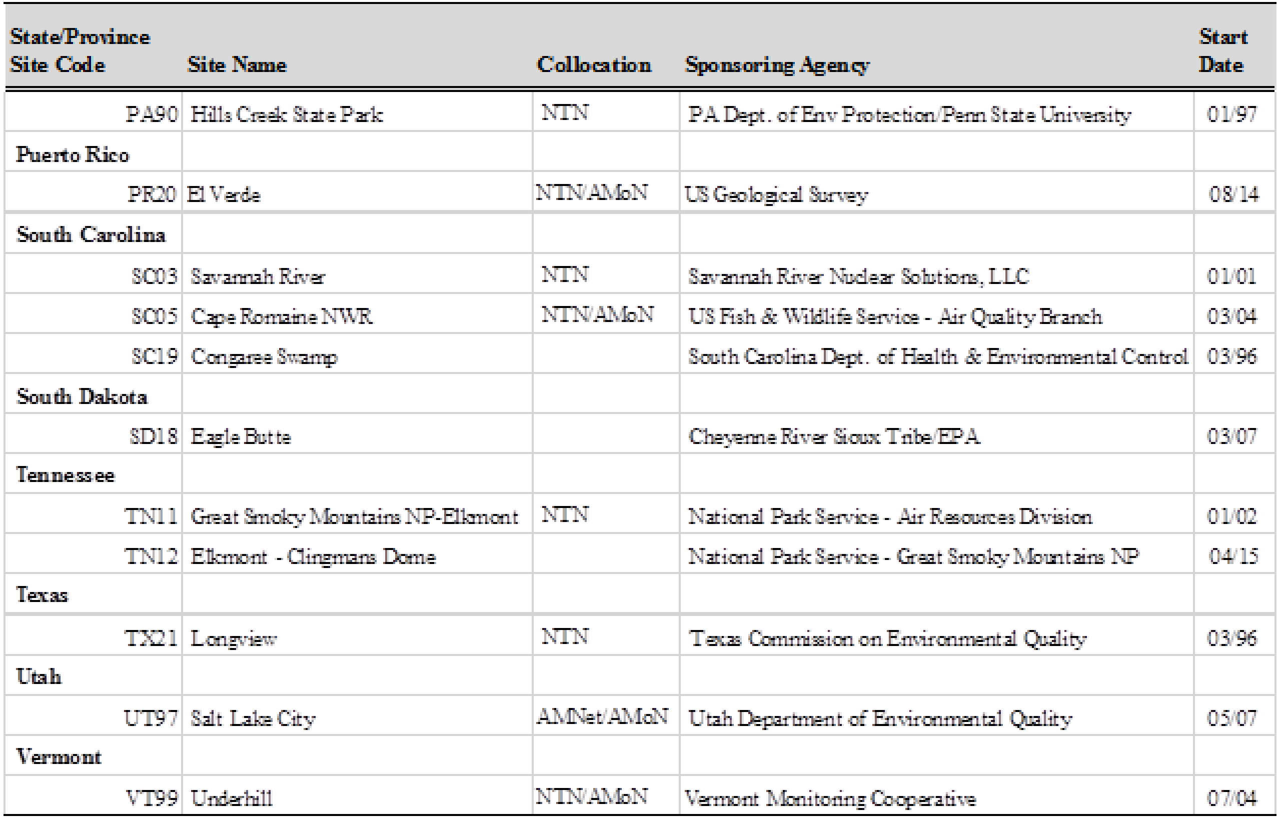
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Florida				
FL05	Chassahowitzka NWR	NTN	US Fish & Wildlife Service - Chassahowitzka NWR	07/97
FL11	Everglades NP - Research Center	NTN/AMoN	South Florida Water Management District	03/96
FL95	Everglades - South Palm Beach County		South Florida Water Management District	04/15
FL97	Everglades - Western Broward County		South Florida Water Management District	11/06
Georgia				
GA09	Okefenokee NWR	NTN	US Fish & Wildlife Service - Air Quality Branch	07/97
Illinois				
IL11	Bondville	AIRMoN/NTN/AMoN	Illinois State Water Survey/NADP	01/99
Indiana				
IN21	Clifty Falls State Park	AMNet	Lake Michigan Air Directors Consortium - LADCO	01/01
IN22	Southwest Purdue Agricultural Center	NTN/AMoN	Lake Michigan Air Directors Consortium - LADCO	12/13
IN34	Indiana Dunes National Lakeshore	NTN	Lake Michigan Air Directors Consortium - LADCO	10/00

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

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

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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
North Carolina				
NC08	Waccamaw State Park		North Carolina Dept. of Environment & Natural Resource	02/96
NC17	Greensboro	NTN	North Carolina A&T State University	01/15
NC26	Candor	AMoN	North Carolina Dept. of Environment & Natural Resource	11/05
North Dakota				
ND01	Lostwood National Wildlife Refuge		US Fish & Wildlife Service - Air Quality Branch	11/03
Ohio				
OH02	Athens Super Site	AMNet/AMoN	Ohio Environmental Protection Agency	12/04
OH52	South Bass Island	AMNet	Ohio Environmental Protection Agency	05/14
Oklahoma				
OK01	McGee Creek		Oklahoma Department of Environmental Quality	10/06
OK04	Lake Murray		Oklahoma Department of Environmental Quality	10/07
OK06	Wichita Mountains NWR		Oklahoma Department of Environmental Quality	11/07
OK31	Copan		Oklahoma Department of Environmental Quality	10/06
OK99	Stilwell	AMNet/AMoN	Cherokee Nation/EPA	04/03
Pennsylvania				
PA00	Arendtsville	NTN/AMoN	PA Dept. of Env Protection/Penn State University	11/00
PA13	Allegheny Portage Railroad NHS	NTN	PA Dept. of Env Protection/Penn State University	01/97
PA18	Young Woman's Creek	NTN	PA Dept. of Env Protection/Penn State University	10/13
PA30	Erie	NTN	PA Dept. of Env Protection/Penn State University	06/00
PA37	Waynesburg		Electrical Power Research Institute	05/99
PA42	Leading Ridge	NTN	PA Dept. of Env Protection/Penn State University	03/10



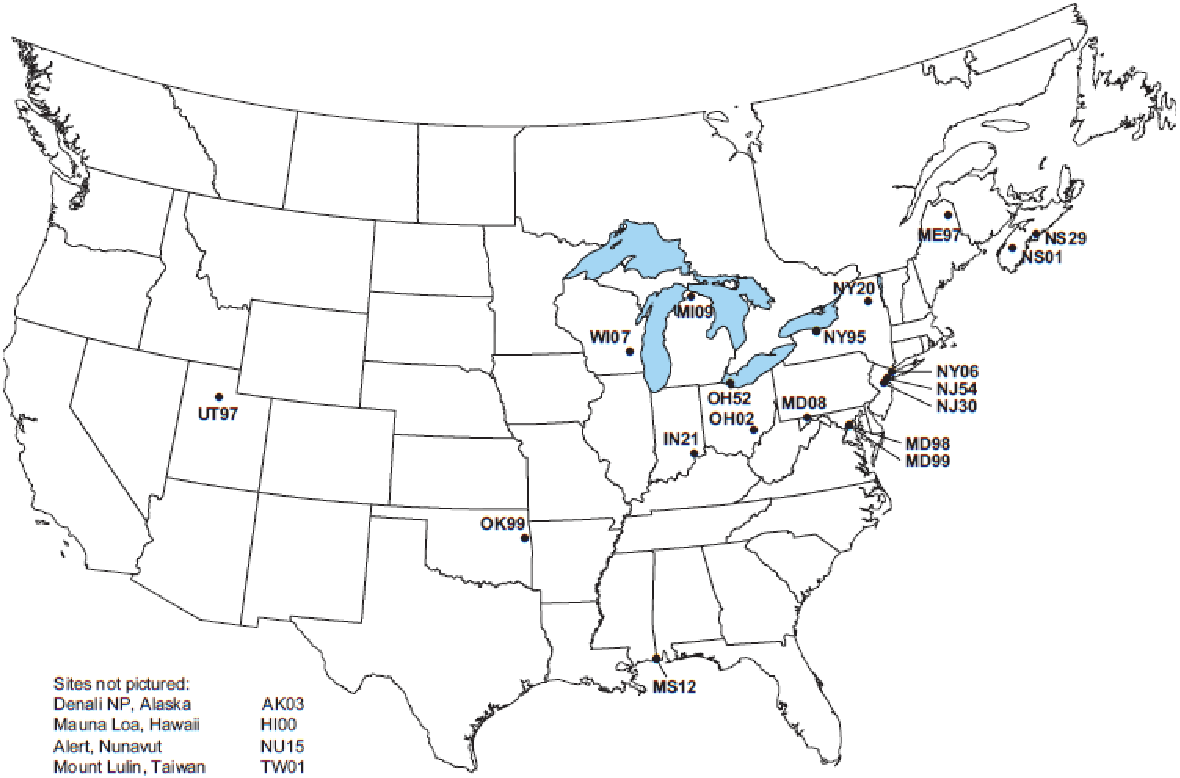
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
PA90	Hills Creek State Park	NTN	PA Dept. of Env Protection/Penn State University	01/97
Puerto Rico				
PR20	El Verde	NTN/AMoN	US Geological Survey	08/14
South Carolina				
SC03	Savannah River	NTN	Savannah River Nuclear Solutions,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

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

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

AMNet Map and Site Listings

National Atmospheric Deposition Program
Atmospheric Mercury Network



Sites not pictured:	
Denali NP, Alaska	AK03
Mauna Loa, Hawaii	HI00
Alert, Nunavut	NU15
Mount Lulin, Taiwan	TW01

National Atmospheric Deposition Program/Atmospheric Mercury Network Sites

July 31, 2017

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alaska				
AK03	Denali National Park	NTN	National Park Service - Air Resources Division	03/14
Hawaii				
HI00	Mauna Loa		National Oceanic & Atmospheric Administration	12/10
Indiana				
IN21	Clifty Falls	MDN	Lake Michigan Air Director's Consortium (LADCO)	05/16
Maine				
ME97	Presque Isle		Aroostook Band of Micmacs	12/13
Maryland				
MD08	Piney Reservoir	MDN/NTN/AMoN	State of Maryland	01/08
MD99	Beltsville	MDN/NTN/AMoN	NOAA/US Environmental Protection Agency-CAMD	11/06
Mississippi				
MS12	Grand Bay NERR	MDN/NTN	National Oceanic & Atmospheric Administration	09/06

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
New Jersey				
NJ30	New Brunswick	MDN	US Environmental Protection Agency - CAM	10/15
NJ54	Elizabeth Lab		US Environmental Protection Agency - CAM	10/15
New York				
NY06	New York City	MDN/NTN	State of New York	08/08
NY20	Huntington Wildlife Forest	MDN/NTN/AMoN	NYSERDA	11/07
NY43	Rochester B	MDN/NTN	State of New York	09/08
Ohio				
OH02	Athens Super Site	AMoN/MDN	Lake Michigan Air Directors Consortium	01/07
OH52	South Bass Island	MDN	Lake Michigan Air Directors Consortium	12/11
Oklahoma				
OK99	Stillwell		US Environmental Protection Agency - CAM	10/08
Utah				
UT97	Salt Lake City	MDN/AMoN	State of Utah	11/08

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wisconsin				
WI07	Horicon Marsh	AMoN	WI DNR	01/11
Canada				
NS01	Kejimkujik NP	MDN/AMoN	Environment Canada	01/09
NU15	Alert		Environment Canada	01/06
Taiwan				
TW01	Mt. Lunil		Taiwan EPA	01/10

Proceedings Notes

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

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

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

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

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

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