NADP Total Deposition Science Committee (TDep) Annual Report 2019

Contents

Introduction

The National Atmospheric Deposition Program (NADP) Science Committees focus on key areas of atmospheric deposition, scientific interest and/or applications. They are approved by the NADP Executive Committee and must be dissolved or renewed every four years. The Total Deposition Science Committee (TDep) was established in 2011 and its mission is to improve estimates of atmospheric deposition by advancing the science of measuring and modeling atmospheric wet, dry, and total deposition. TDep provides a forum for the exchange of information on current and emerging issues among atmospheric scientists, ecosystem scientists, resource managers, and policy makers. The committee is open to anyone interested in contributing the mission. The specific charges of TDep are:

- Support the national networks that monitor atmospheric deposition by providing information on emerging measurement techniques, model development, and uncertainties associated with these approaches;
- Identify and prioritize knowledge gaps in the field of measuring and modeling atmospheric deposition and advocate for research to address those gaps;
- Coordinate with Critical Loads of Atmospheric Deposition Science Committee (CLAD) and other groups to advocate the use of the most scientifically defensible deposition estimates for critical loads and other environmental assessments;
- Provide expertise and advice on present and potential decisions and regulatory actions pertaining to the field of measuring and modeling atmospheric deposition; and
- Encourage greater communication and collaboration between groups from different disciplines and countries with interests in atmospheric deposition.

Additional information can be found on the TDep website (http://nadp.slh.wisc.edu/committees/tdep/).

TDep is currently headed by two **Co-chairs**, John Walker (U.S. Environmental Protection Agency; EPA/ Office of Research and Development; ORD) and Greg Beachley (EPA/Office of Air and Radiation; OAR). Selma Isil (Wood, Inc) is the TDep **Secretary**. The TDep Steering Committee meets bi-monthly to establish meeting agendas, share information on upcoming opportunities for outreach, and identify project priorities. The **Steering Committee** is made up of past Co-chairs, Working Group leaders, and federal agency representatives. Steering Committee members include: John Walker, Greg Beachley, Selma Isil, Tom Butler (Cornell University), Bret Schichtel (National Park Service; NPS), Chris Rogers (Wood), Amanda Cole (Environment Climate Change Canada; ECCC), David Schmeltz (EPA/OAR), Katie Benedict (Colorado State University), Kristi Morris (NPS), Mike Bell (NPS), Rob Pinder (EPA/OAR), and Donna Schwede (EPA/ORD). The Steering Committee will provide the Executive Committee with an update on how they have fulfilled the science committee's mission and charges over the previous 4 years during the Spring 2020 meeting for TDep's request for renewal.

In 2019, TDep adopted a workgroup format to increase structure and organization within the committee. This format will help to distribute workloads, provide more accessibility of projects and opportunities to committee members and promote more collaborative work. Descriptions and updates from these workgroups are included herein.

This annual report serves as a summary and quick reference for the activity, progress, and accomplishments of TDep over the course of the past year (May 2019 –April 2020). It contains links to

the biannual meeting notes, updates from each of the TDep workgroups, and descriptions and status updates on TDep-related products and research.

Summary of TDep Accomplishments

It was another productive year for TDep. Below is a snapshot of the May 2019 – April 2020 accomplishments.

The **TDep White Paper** "Science needs for continued development of total nitrogen deposition budgets in the United States" was finalized and posted to our website in May 2019. *https://nadp.slh.wisc.edu/committees/tdep/reports/nrDepWhitePaper.aspx*. Thank you to all who contributed.

Peer-reviewed summary articles related to the TDep White Paper were published to the July 2019 issue of AWMA's EM magazine "*Improving Nitrogen Deposition Budgets in the United States"*. The EM articles can be found on the TDep website (http://nadp.slh.wisc.edu/committees/tdep/reports/EMissue2019/). TDep members also contributed an article on U.S.-Canada collaboration on nitrogen and sulfur deposition to the June 2019 issue of EM magazine, "*Cross Border Environmental Issues*."

A Virtual Special Issue of Science of the Total Environment (STOTEN) on Reactive Nitrogen Deposition was published (*https://www.sciencedirect.com/journal/science-of-the-total-environment/special-issue/10L3T8MRVHD*) that included nine peer-reviewed articles that were related to the TDep White Paper. Co-chairs John Walker and Greg Beachley were guest editors for this issue. Specific references are listed in the Publications section of this report. The papers from the special issue can be found on the NADP website (http://nadp.slh.wisc.edu/committees/tdep/reports/stoten/).

Another effort stemming from the TDep White paper is a monthly webinar series (the 3rd Wednesday at 2pm ET) organized by National Park Service (Mike Bell, Kristi Morris). Lead authors summarize their specific scientific topic included in White Paper. The webinars are recorded and can found on the TDep website (*https://nadp.slh.wisc.edu/committees/TDep/webinars/*).

The NADP hosted a TDep Workshop *'Connecting Stakeholder and Science Perspectives to Better Understand the Linkages Between Agriculture and Reactive Nitrogen Deposition' (https://nadp.slh.wisc.edu/nadp2019/TDepworkshop.asp)* at the 2019 NADP Science Symposium held in Boulder, CO. This took the place of the TDep committee meeting. The workshop was attended by ~100 participants.

In lieu of the Fall TDep Science Committee meeting, a newsletter summarizing ongoing projects and workgroup updates was distributed to the mailing list. Please see *https://nadp.slh.wisc.edu/committees/tdep/minutes.aspx* for details from that newsletter and the 2019 Spring meeting minutes from Madison, WI.

General Updates.

John Walker, the current TDep Co-chair, was elected NADP Secretary at the Fall 2019 Executive Committee Meeting. TDep will nominate and elect a new Co-chair during the Spring 2020 virtual meeting to replace John.

The Education and Outreach Subcommittee (EOS) developed new charges at the Fall 2019 Executive Committee Meeting. As part of this reorganization, EOS has requested that each subcommittee have at least one representative attend the EOS meetings. Chris Rogers and Kristi Morris are the **TDep representatives to EOS**.

TDep Workgroups

In 2019, TDep adopted a Workgroup structure in order to increase structure and organization, and to promote collaborative work. It is hoped that the new format will help to distribute workloads, make projects more accessible to a broader audience, and further research between the spring and fall meetings.

The current workgroups include:

- Stakeholder Workgroup (Lead: John Walker)
- Measurement Model Fusion (MMF) Workgroup (Lead: Greg Beachley)
- Deposition Uncertainty Workgroup (Lead: Mike Bell)

TDep will also host the Urban Deposition Science Committee (CityDep) chaired by Greg Wetherbee (US Geological Survey; USGS) at our biannual meetings. There are many overlapping objectives between CityDep and TDep, particularly in understanding urban deposition and its spatial variability and better representing urban deposition in TDep deposition maps.

Stakeholder Workgroup *Lead:* John Walker, EPA (walker.johnt@epa.gov)

Workgroup Objectives:

- Increase communication across scientific communities (i.e., atmospheric chemistry, ecology)
- Create new opportunities for collaborative research by promoting the inclusion of deposition science in grant programs
- Advance the integration of TDep science needs into existing research programs across stakeholder groups
- Facilitate communication among program managers within stakeholder Agencies and user groups

Current Projects:

- Development of outputs from Fall 2019 TDep Workshop 'Connecting Stakeholder and Science Perspectives to Better Understand the Linkages Between Agriculture and Reactive Nitrogen Deposition' *(https://nadp.slh.wisc.edu/nadp2019/TDepworkshop.asp).* Outputs will include a workshop report to be posted on the NADP website, a TDep agricultural stakeholder outreach plan and potentially a communication piece for an agricultural journal or trade magazine.

- Participation in USDA North Central Regional Development Committee Project developed by Rich Grant and colleagues: 'NCDC233 Sources and Fate of NH_3 Across the Region'

Measurement Model Fusion Workgroup *Lead:* Greg Beachley, EPA (beachley.gregory@epa.gov)

The objective of this workgroup is to be the caretakers of the TDep MMF grids and product output. Workgroup members will conduct research and have discussions to ensure that the TDep MMF stays current with the state of deposition science. The group will respond to any questions and requests involving the TDep MMF products. The workgroup will meet quarterly.

In 2019, the annual maps were produced using the 2018 measurement data (version 2018.02). This version still uses the 2002 to 2012 CMAQ v5.0.2 modeled time series. The grids and images are available at https://nadp.slh.wisc.edu/committees/tdep/tdepmaps/. The 2017 TDep Map Summary was produced and is available on the TDep website (https://nadp.slh.wisc.edu/committees/tdep/reports/).

Current Projects:

- Continue to work on the long-anticipated TDep MMF script conversion. The work is included as a Task Order under EPA's Clean Air Status and Trends Network (CASTNET) Operations contract with Wood. Wood selected a subcontractor, Sonoma Technology, Inc. (STI), to perform the work which includes re-writing the current AML and perl scripts in Python and ArcPy. The goal for releasing the new TDep product is the Fall of 2020.
- The CMAQ v5.3 model runs (2000 to 2017) are slated to be finished in Q1 of 2021 and will be considered in the script conversion. A draft plan for comparisons using the 'anchor year' of 2010 is planned to quantify any changes that result from the new method or the new CMAQ v5.3 time series.

Deposition Uncertainty Workgroup

Lead: Mike Bell, NPS (michael_d_bell@nps.gov)

Workgroup Objectives:

- Understand the uncertainty in measurements and models for deposition estimates
- Assess deposition measurements (bulk precipitation collectors, ion exchange resin (IER) columns, snowpack, and lichen tissue)
- Evaluate deposition model estimates (CMAQ, TDEP, CAMx, and ADAGIO) and compare to measurements to assess the spatial variability of uncertainty
- Develop a framework of comparability of critical loads (CLs) developed from different data sources

Current Projects:

- Evaluation of how using different models (CMAQ, TDep, CAMx, and ADAGIO) impacts the exceedance of CLs in Class I areas (NPS-led).

- Downscaling deposition model data to land use type to develop more spatially explicit deposition data (EPA-led)
- Throughfall measurement database (CLAD; M. Bell)
- Weighted Deposition Uncertainty Metric (WDUM; Walker et al., 2019 and chapter in TDep White Paper) and applying to near CL exceedance areas.

TDep Project Queue and On-going Work

Currently compliling a "TDep project queue" to track projects and current research motivated by the TDep mission. This list will be presented at biannual TDep meetings to solicit audience feedback and endorsement of the project list.

- **AMoN Flux Characterization Pilot Study update**

A project is currently underway (EPA/Wood, Inc) to develop a methodology to estimate net and component NH_3 fluxes using two-week integrated NH_3 concentrations at AMoN sites. During Phase I of the project, which is now complete, measurements of micrometeorology, biogeochemistry, and canopy physical characteristics were collected at three AMoN sites: Duke Forest, NC; Bondville, IL; and Chiricahua National Monument, AZ. During Phase II of the project, these measurements will be used to parameterize a bidirectional NH_3 model for implementation across the AMoN network, including assessment of uncertainties associated with the use of time-integrated concentration measurements, use of modeled meteorological inputs, and parameterizations of soil and vegetation emission potentials. A summary report on the measurement results will be published in the summer of 2020.

- **Reactive N flux measurements by eddy covariance**

Thermal and photolytic converter methods can be combined with fast nitric oxide chemiluminescence detection to quantify canopy-scale fluxes of reactive N by eddy covariance. A project is underway (EPA/Wood, Inc) to develop an inlet system for a two-channel chemiluminescence instrument for deployment at Duke Forest. The inlet system will include a photolytic converter for NO_2, a heated molybdenum converter for total NOy, and a heated stainless-steel converter for total reactive N. By employing dual chemiluminescence reaction cells, fluxes can be measured in one of two modes for continuous concurrent flux measurements of (Mode 1) NO_2 and total NOy or (Mode 2) total NOy and total reactive N. This combination of fluxes allows for assessment of the contribution of NO_2 to total NOy fluxes and, by comparing total NOy and total reactive N, the relative fractions of reduced versus oxidized forms of reactive N dry deposition.

- **Low-cost dry deposition system**

Datasets of dry deposition of reactive nitrogen are lacking due to the cost and complexity of online micrometeorological flux measurements. A low-cost dry deposition measurement system suitable for routine network operation is needed. A project is underway (EPA) to construct and test a conditional time-averaged gradient (COTAG) system for measurement of speciated dry deposition of reactive N (NH_3, HNO_3, HONO, NO_3^-, NH_4^+) on weekly to monthly time-scales.

- **Water soluble organic nitrogen pilot study status**

EPA and Wood are conducting a special study using data collected from five CASTNET sites: Great Smoky Mountain National Park, TN; Kickapoo Tribe in Kansas, KS; Rocky Mountain National Park, CO; Salamonie Reservoir, IN; and Washington Crossing State Park, NJ. The study involves analyzing the Teflon filter extracts (which measures particles) for total nitrogen. The Teflon filter is the first of three filters in the CASTNET filter pack's standard configuration. During 2019, methods were developed, and a Shimadzu total carbon/total nitrogen instrument was installed in Wood's Gainesville, FL laboratory. In early 2020, Wood analyzed samples measured between January through March. Water soluble organic nitrogen (WSON) will be calculated as the difference between the total nitrogen measured by the Shimadzu and the particulate NO_3^- and NH_4^+ measured using standard CASTNET methods.

- **Flux metadatabase**

During early 2018, TDep developed a questionnaire requesting input from scientists around the world regarding completed flux measurement campaigns. The goal of this effort was to collect metadata for different studies including Principal Investigator, location, parameters measured, land use and cover, relevant publications, etc. John Walker distributed the questionnaire to his list of colleagues and multiple responses were received. Outreach continued during 2019 and to-date there are 14 studies included in the metadata database. The questionnaire will be published on the NADP TDep web site along with an online questionnaire that will make it easier for future entries to be included.

- **Improving characterization of reduced nitrogen at IMPROVE and CSN monitoring sites**

The goal of increasing reduced nitrogen measurements remains important for the TDep community and is shared by other monitoring groups and existing networks. There has been interest over the years in exploring the use of acid-impregnated filters that could be added to sites in existing networks such as IMPROVE and CSN. Chen et al. (2014) used acid-impregnated filters deployed as part of the IMPROVE at sites primarily in Colorado and other western states. EPA, NPS, and Wood collaborated to run a similar set up for IMPROVE equipment plus a CSN module with an impregnated filter during the 2017 warm season at two sites in the southeastern United States (Duke Forest, NC and Gainesville, FL). Data analysis occurred during late 2017 and 2018, and a summary report was completed during 2019. It was found that high humidity (particularly at the study site in Florida) appears to interfere with the collection of reduced nitrogen using impregnated filters. Overall, IMPROVE and CSN NHx measurements correlated better with the reference method (annual denuder filter pack systems) at Duke Forest, NC compared to Gainesville, FL site indicating that further study is needed to assess NHx method performance at coastal and other high-humidity sites.

- **Developing FACT Sheet on White Paper**

Current effort to highlight the TDep White Paper in a 1-page fact sheet is underway and being led by Kristi Morris. The effort will focus on creation of visuals and discussion of research areas and projects that will address key scientific knowledge gaps that will require collaborative efforts between multiple agencies and scientific groups. This material is discussed in more detail in the White Paper section 4 "Enhanced Coordination to Address Stakeholder Issues and Resource Needs".

- **WMO Measurement-Model Fusion for Global Total Atmospheric Deposition Initiative**

TDep members Amanda Cole and Donna Schwede are members of a new steering committee for the WMO initiative MMF-GTAD. The long-term goal of this initiative is to use to produce high-quality maps and estimates of fluxes of atmospheric pollutants on a global scale in a semi-operational manner, drawing from the methods and expertise of TDep and other regional MMF deposition products. Short-term projects include an overview paper, an initial proof-of-concept set of maps for a single year, and extension of a Swedish MMF product over Europe.

TDep Publications

The following articles were published in the July 2019 issue "Improving Nitrogen Deposition Budgets in the United States" of EM magazine, copyrighted publication of the Air & Waste Management Association and accessible here http://nadp.slh.wisc.edu/committees/tdep/reports/EMissue2019/

- Walker, J.T. Improving Nitrogen Deposition Budgets for Ecosystem Assessments in the United States.
- Walker, J.T. and Beachley, G.M. Evolution of Monitoring and Modeling or Reactive Nitrogen Deposition in the United States.
- Beachley, G.M., Rogers, C.M., Lavery, T.F., Walker, J.T., Puchalski, M. A. Long-Term Trends in Reactive Nitrogen Deposition in the United States.
- Puchalski, M.A., Walker, J.T., Beachley, G.M., Zondlo, M.A., Benedict, K. B., Grant, R.H., Schichtel, B.A., Rogers, C.M., Leytem, A.B., Rice, J., Morris, K.M., Schauer, J. J. Wang, R. Need for Improved Monitoring of Spatial and Temporal Trends of Reduced Nitrogen.

References for Virtual Special Issue of Science of the Total Environment (https://www.sciencedirect.com/journal/science-of-the-total-environment/special-issue/10L3T8MRVHD) are listed below:

- Emily M. Elliott, Zhongjie Yu, Amanda S. Cole, Justin G. Coughlin. 2019. Isotopic advances in understanding reactive nitrogen deposition and atmospheric processing. Sci Tot. Environ. 662. 393-403. https://doi.org/10.1016/j.scitotenv.2018.12.177
- Abigail S. Hoffman, Shannon E. Albeke, Jill A. McMurray, R. David Evans, David G. Williams. 2019. Nitrogen deposition sources and patterns in the Greater Yellowstone Ecosystem determined from ion exchange resin collectors, lichens, and isotopes. Sci Tot. Environ. 683. 709-718. https://doi.org/10.1016/j.scitotenv.2019.05.323
- Bret A. Schichtel, Kristi A. Gebhart, Kristi H. Morris, James R. Cheatham, John Vimont, Robert S. Larson, Gregory Beachley. 2019. Long-term trends of wet inorganic nitrogen deposition in Rocky Mountain National Park: Influence of missing data imputation methods and associated uncertainty. Sci Tot. Environ. 687. 817-826. https://doi.org/10.1016/j.scitotenv.2019.06.104
- John T. Walker, Michael D. Bell, Donna Schwede, Amanda Cole, Greg Beachley, Gary Lear, Zhiyong Wu. 2019. Aspects of uncertainty in total reactive nitrogen deposition estimates for North American critical load applications. Sci Tot. Environ. 690. 1005-1018. https://doi.org/10.1016/j.scitotenv.2019.06.337

- Gregory A. Wetherbee, Katherine B. Benedict, Sheila F. Murphy, Emily M. Elliott. 2019. Inorganic nitrogen wet deposition gradients in the Denver-Boulder metropolitan area and Colorado Front Range – Preliminary implications for Rocky Mountain National Park and interpolated deposition maps. Sci. Tot. Environ. 691. 1027-1042. https://doi.org/10.1016/j.scitotenv.2019.06.528
- John T. Walker, Greg Beachley, Helen Amos, Jill S. Baron, et al. 2019. Toward the improvement of total nitrogen deposition budgets in the United States. Sci. Tot. Environ. 691. 1328-1352. https://doi.org/10.1016/j.scitotenv.2019.07.058
- John T. Walker, Gregory Beachley, Leiming Zhang, Katherine B. Benedict, Barkley C. Sive, Donna B. Schwede. 2020. A review of measurements of air-surface exchange of reactive nitrogen in natural ecosystems across North America. Sci. Tot. Environ. 698. 133975. https://doi.org/10.1016/j.scitotenv.2019.133975
- Rodolfo Sosa Echeverria, Ana Luisa Alarcón Jimenez, María del Carmen Torres Barrera, Pablo Sánchez Alvarez, Monica Jaimes Palomera, Elias Granados Hernandez, David Gay. 2020. Sulfur and nitrogen compounds in wet atmospheric deposition on the coast of the Gulf of Mexico from 2003 to 2015. Sci. Tot. Environ. 700. 134419. https://doi.org/10.1016/j.scitotenv.2019.134419
- Jordan Baker, William H. Battye, Wayne Robarge, S. Pal Arya, Viney P. Aneja. 2020. Modeling and measurements of ammonia from poultry operations: Their emissions, transport, and deposition in the Chesapeake Bay. Sci. Tot. Environ. 706. 135290 https://doi.org/10.1016/j.scitotenv.2019.135290