NADP Total Deposition Science Committee (TDep) Annual Report 2021

Contents

Introduction

The National Atmospheric Deposition Program's (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 the charter was most recently renewed in 2020. The TDep 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 to 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 bridge those gaps;
- Coordinate with NADP's Critical Loads of Atmospheric Deposition (CLAD) Science Committee and other groups to advocate for 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 directed by two **Co-chairs**, Greg Beachley (U.S. Environmental Protection Agency; EPA/Office of Air and Radiation; OAR), and Ryan Fulgham (EPA/Office of Research and Development; ORD). Amanda Cole (Environment Climate Change Canada; ECCC) 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, EOS representatives, representatives of major NADP-funding agencies, and atmospheric and ecosystem scientists closely involved with the TDep mission. For 2021, the Steering Committee members included: Greg Beachley, Ryan Fulgham, Amanda Cole, Mike Bell, Katie Benedict (Los Alamos National Laboratory) (National Park Service; NPS), Selma Isil (Wood), Chris Rogers (Wood), Kristi Morris (NPS), Melissa Puchalski (EPA/OAR), Bret Schichtel (NPS), Donna Schwede (EPA/ORD), John Walker (EPA/ORD), and Greg Wetherbee (U.S. Geological Survey; USGS).

TDep is organized into a workgroup format to provide structure and organization within the committee. This format helps 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 2021. 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.

Annual Summary of TDep Accomplishments

It was another productive year for TDep. Below is a snapshot of the 2021 accomplishments.

- **Fact sheet on the TDep White Paper was completed.** The fact sheet focuses on visuals and discussion of research on key scientific knowledge gaps that 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".

- **Modernization and transcription of the TDep Measurement Model Fusion (MMF) was completed.** The new version will be 2021.01 and is written in Python and ArcPy and requires ArcGISPro 2.4 or higher. A manuscript is in preparation detailing the process and evaluation of results between the modernized and old version (2018.02) and is detailed later in the TDep Project Tracker.

- **Development and Incorporation of EQUATES deposition time-series using CMAQ v5.3.2 (2002 to 2017) into the modernized TDep MMF scripts (Measurement Model Fusion Workgroup).** Kristen Foley (EPA/ORD) lead the EPA's Air QUAlity TimE Series Project (EQUATES) to produce a deposition time-series dataset spanning 2002 - 2017 that was successfully incorporated into the modernized TDep measurement model fusion (MMF). An evaluation of the 2010 model year (chosen as other modeling platforms e.g. ADAGIO has data for this year) will be included in the manuscript (see previous bullet) and in more detail in the TDep Project Tracker.

- **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 is available (https://www.epa.gov/castnet/castnet-special-studies).

General Updates

Amanda Cole was elected as TDep secretary at the Fall 2021 virtual TDep meeting, Ryan Fulgham was promoted to TDep Co-chair.

The Education and Outreach Subcommittee (EOS) enacted guidance that biannual meeting notes for each committee should be approved electronically approximately 6 weeks after convening to help meet committee objectives more effectively between each meeting.

Due to the pandemic, TDep held virtual meetings for the Spring and Fall 2021. Feedback was largely positive on the meetings. We hope to incorporate some level of virtual participation when in-person meetings resume.

TDep Workgroup Updates

In 2019, TDep adopted and organized into a Workgroup structure 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 advance 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)
- Urban Deposition Workgroup (CityDep; Lead: Greg Wetherbee)

An 'intent to form' announcement was made in the Spring 2021 for a Measurement and Monitoring workgroup, but no workgroup lead has been identified.

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

Examples of Current Projects (Project descriptions listed in TDep Project Tracker):

- 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).* In addition to the workshop summary report mentioned above, a TDep agricultural stakeholder outreach plan is

being developed with intentions of creating an article for an agricultural journal or trade magazine.

- Participation in USDA North Central Regional Development Committee Project developed by Rich Grant (Purdue University) and colleagues: 'NCDC233 Sources and Fate of NH_3 Across the Region'. The first annual meeting was held virtually on November 30th 2021. Project leads were identified to coordinate research around the three research objectives. The participants will meet again in the Spring prior to the NADP meeting.

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 outputs (https://nadp.slh.wisc.edu/committees/tdep/). 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 questions and requests involving the TDep MMF products. The workgroup will meet quarterly.

In 2021, the group established focus task-groups to further breakdown the workload and improve collaboration. The task-groups include Product Development, Outreach, and Improvements. The Product Development Taskgroup will improve methods and efficiency of quality assurance/quality control procedures for the TDep MMF product. The Outreach task-group will focus on the TDep Total Deposition maps website and product updates. This task-group will focus on messaging (i.e. social media alerts) and identifying new stakeholders and collaborators. The Improvements task-group will focus on long-term improvements to the TDep MMF and helping to keep the TDep MMF current with the state of the science.

Examples of Current Projects (Project descriptions listed in TDep Project Tracker):

- Completion of the full year set of modernized TDep MMF (2021.01) runs spanning from 2000 to 2020.
- A publication focusing on deposition trends estimated from the AML TDep MMF method for 2000 to 2018 is in preparation.
- A comparison summary of deposition trends predicted with the modernized and archived TDep MMF methods.
- Incorporation of CMAQ wet deposition data into the TDep MMF model

Deposition Uncertainty Workgroup

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

Workgroup Objectives:

To better understand uncertainty in deposition measurements and models and how it effects the calculation and exceedance if critical loads. These questions are pursued through:

- Evaluating the differences in deposition model outputs, deposition measurements, and actual deposition rates and how these vary along environmental gradients and across ecosystems.
- Assessing deposition measurement methods (bulk precipitation collectors, ion exchange resin (IER) columns, snowpack, and lichen tissue) in comparison to modeled values.
- Evaluating deposition model estimates (CMAQ, TDep, CAMx, and ADAGIO) and compare to measurements to assess the spatial variability of uncertainty.
- Developing a framework to identify impacts of evaluating critical load (CLs) exceedances with a single deposition model when CLs are developed from different data sources.

Examples of Current Projects:

- Evaluation of how using different models (CMAQ, TDep, CAMx, and ADAGIO) impacts the exceedance of CLs in Class I areas (NPS-led).
- Comparison between throughfall deposition and eddy covariance measurements to estimate collection efficiency (EPA-led).
- Comparison between IER throughfall deposition collectors and TDep/CMAQ models to evaluate consistency of model uncertainty across multiple ecosystems (NPS-led).
- Disaggregating 12-km CMAQ dry deposition data to a 500m scale using land use specific deposition rates to more accurately assess deposition rates and how they impact critical load exceedances (EPA-led).

Urban Deposition Workgroup (CityDep)

Lead: Greg Wetherbee, USGS (wetherbe@usgs.gov)

Workgroup Objectives:

- The mission of the CityDep Work Group is to enhance the National Atmospheric Deposition Program by expanding monitoring and other data-gathering opportunities through collaborative research on air-quality and atmospheric deposition of pollutants and their effects on ecological and public health in urban environments.

Examples of Current Projects:

- A Research Coordination Network proposal to the National Science Foundation is in progress, currently led by Alexandra Ponette. The idea was brought forward by Rich Pouyat in 2019 to fund outreach to cities to promote ambient air and deposition monitoring.
- Analysis of data collected by the Network for Urban Atmospheric Nitrogen Chemistry (NUANC) is continuing and have been used in Wetherbee et al., 2022 (see TDep Publications) and two publications in review

TDep Project Tracker

TDep uses the annual report to communicate a "TDep Project Tracker". The objectives of the project tracker are to 1) allow TDep members to highlight research and products motivated by or relevant to the TDep mission and 2) log ideas that cannot be currently acted on so that they are not lost. The TDep Project Tracker will be included in each year's annual report and will be presented and discussed at biannual TDep meetings to solicit audience feedback and endorsement.

Current Research and products motivated by or relevant to the TDep mission

- **AMoN Flux Characterization Pilot Study update (John Walker, EPA)**

A project is currently underway (EPA/Wood) to develop a methodology to estimate net and component NH_3 fluxes using two-week integrated NH_3 concentrations at AMoN sites. An EPA report is near completion (Spring 2022) that describes the Phase I measurements of micrometeorology, biogeochemistry, and canopy physical characteristics at three AMoN pilot sites: Duke Forest, NC; Bondville, IL; and Chiricahua National Monument, AZ. Phase II of the project is progressing, where Phase I 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.

This project directly addresses research gaps presented in the TDep Reactive Nitrogen (Nr) deposition White Paper in applying a bidirectional ammonia air-surface exchange model at NADP AMoN sites (See White Paper section 3.2.1).

- **Reactive N flux measurements by eddy covariance (John Walker, EPA)**

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) 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. The Total N, NOy, NO_2 converter/inlet system is undergoing laboratory testing at EPA with deployment at Duke Forest hardwood tower in Spring 2022.

This project directly addresses research gaps presented in the TDep Reactive Nitrogen (Nr) deposition White Paper for process-level flux measurements (see White Paper Sections 3.1.1 and 3.1.1.1).

- **Low-cost dry deposition system (John Walker, EPA)**

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. In collaboration with USDA, EPA has constructed and is testing 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. One COTAG system was upgraded in October 2021 and will be deployed spring 2022 to a new site in Idaho. A second system with improved flow monitoring is complete and deployed in Idaho. A third system will be constructed and deployed at Duke Forest in summer 2022. A design package for the EPA COTAG, including mechanical drawings, wiring schematics, field and lab SOPs, has also been completed.

This research project directly addresses research gaps presented in the TDep Reactive Nitrogen (Nr) deposition White Paper in 3.1 Measured total Nr deposition budgets, particularly for 3.1.2.4. Low-cost method for routine monitoring of air-surface exchange of Nr compounds.

- **Water soluble organic nitrogen (WSON) aerosol pilot study status (John Walker, EPA)**

EPA and Wood conducted a special study using samples 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 involved analyzing the Teflon filter extracts (the 1st stage in the CASTNET filter pack which captures particles) for total nitrogen. Precision and detection limits for total N and total water soluble organic nitrogen (WSON), calculated as the difference between a Shimadzu combustion/chemiluminescence total nitrogen measurement and the particulate NO_3^- (ion chromatography) and NH_4^+ (colorimetry) measured using standard CASTNET methods were assessed.

In early 2021, a 12-week study of more comprehensive testing of sample handling and storage effects on WSON was conducted. Split samples were analyzed from a test site in Gainesville and co-located filter packs from Mackville, KY (MCK131/231). The results indicated that further testing was needed to reduce the blank values and improve precision. While the results have since improved, EPA has decided to delay the next phase of the study so that a new Seal Analytical colorimetric autoanalyzer can be used for the total N analysis. Use of colorimetry for both Total N and NH_4^+ will reduce instrument cross-calibration requirements and will be consistent with the WSLH SNiPiT method for Total N in precipitation. A 12-month study will be conducted once Wood receives a new SEAL total N analyzer in the spring of 2022 and initial QA/QC testing is completed. Filters from 27 CASTNET sites (25 locations) will be analyzed for Total N once the new analyzer is online. A subset of sites will also receive the SNiPiT wet deposition total N/total P collector for co-located measurements of total and organic N in aerosols and precipitation.

This project directly addresses research gaps presented in the TDep Reactive Nitrogen (Nr) deposition White Paper, which include development of routine methods to quantify organic nitrogen in (See White Paper section 3.1, particularly subsections 3.1.2.5 and 3.1.2.4). This project will also advance the science of routine ON measurements (See White Paper section 3.4 specifically subsection 3.4.1).

- **Testing of the NADP total N / total P wet deposition sampler (WLSH)**

The Wisconsin State Laboratory of Hygiene (WSLH) is developing a collector and analytical methods for measurement of total WSON and P in precipitation. The prototype collector (SNIPIT) fits on the outside

of the NTN bucket and is pre-charged with acid to avoid microbial processing and sorption of N and P. Chris Worley presented on the status of this project at the 2021 Fall TDep meeting.

This project directly addresses research gaps presented in the TDep Reactive Nitrogen (Nr) deposition White Paper to develop routine methods to quantify organic nitrogen (See White Paper section 3.1, particularly subsections 3.1.1.1 and 3.1.2.5). This also addresses the knowledge gap for routine ON measurements identified in 3.4, specifically for subsection 3.4.1.

- **WMO Measurement-Model Fusion for Global Total Atmospheric Deposition Initiative (Amanda Cole; Measurement Model Fusion workgroup)**

TDep members Amanda Cole and Donna Schwede are members of a steering committee for the WMO's MMF-GTAD initiative. The long-term goal of this initiative is 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. The overview paper led by Joshua Fu (University of Tennessee) was published in early 2022 in Environmental Science and Technology. A formal project implementation plan was published by WMO in October 2021 (https://library.wmo.int/doc_num.php?explnum_id=10831). Work on the global proof-of-concept maps has begun under the leadership of Jeff Geddes (Boston University), with products expected in 2022.

- **Nitrogen deposition from Agricultural sources and development of Stakeholder engagement plan (Stakeholder Workgroup)**

An outcome from the Fall 2019 TDep Workshop 'Connecting Stakeholder and Science Perspectives to Better Understand the Linkages Between Agriculture and Reactive Nitrogen Deposition' was for the development of a Stakeholder engagement plan. Background and early progress information was presented at the 2020 Fall meeting by Anne Rea, EPA. The initial focus will be on closer engagement with the agricultural community. A draft of the engagement plan will be distributed to the TDep steering committee prior to the spring 2022 meeting.

This research directly addresses research gaps presented in the TDep Reactive Nitrogen (Nr) deposition White Paper to enhance coordination to address stakeholder issues and resource needs (See White Paper section 4).

- **Measurements of NH_3 and other reactive N dry deposition fluxes in Rocky Mountain National Park (RMNP)**

A project funded through an EPA Regional Applied Research Effort (RARE) grant, with additional funding from the National Park Service, is now in its second year. This collaborative project between EPA ORD, EPA Region 8, NPS and Colorado State University (CSU) seeks to measure NH_3 and other reactive N dry deposition fluxes in RMNP and along the NH_3 transport path from agricultural sources on the Front Range to the Park. The first set of flux measurements was collected during the summer of 2021 over an evergreen forest in RMNP. During 2022, flux measurements will be collected at a grassland site between RMNP and the agricultural source region on the Front Range. In addition to direct flux

measurements, seasonal and annual NH_3 fluxes will be modeled at both sites using measurements of NH_3 air concentrations, micrometeorology, and soil and vegetation emission potentials.

This research project directly addresses research gaps presented in the TDep Reactive Nitrogen (Nr) deposition White Paper for 3.4 'Spatial and Temporal Patterns of total Nr deposition', specifically for 3.4.2 'Spatial variability of ammonia in agricultural regions'.

- **Sensitivity of critical loads to modeled deposition estimates (Mike Bell, NPS; Deposition Uncertainty Workgroup)**

A new project from the NPS (Mike Bell), US Forest Service (Mark Fenn), and San Francisco State University (Leora Nanus) compares measured values of N and S throughfall to TDep model outputs from corresponding years. The initial phase of the study will compare deposition measurements from IER columns to modeled data in the western US. Researchers will assess conditions where measurements align best in hopes of advancing our understanding of model uncertainty.

This research project will address research gaps presented in the TDep Reactive Nitrogen deposition White paper (see sections 3.1.1.3 and 3.2.4).

- **Using epiphytic lichen tissue nitrogen content to understand TDep uncertainty in the Pacific Northwest (Deposition Uncertainty Workgroup)**

An on-going project with the NPS (Mike Bell), US Forest Service (Linda Geiser), and Washington State University (Dave Evans/Meaghan Petix) using tissue nitrogen concentrations from epiphytic lichen species as bioindicators of deposition. Correlation of tissue N, tissue isotopic concentration, and deposition values will be evaluated will be evaluated to assess consistency of tissue to model values and better understand deposition patterns on a fine scale.

This research project will address research gaps presented in the TDep Reactive Nitrogen deposition White paper (see sections 3.2.4).

Using disaggregated N deposition model estimates to evaluate critical loads (Deposition Uncertainty Workgroup)

A continuing project with the NPS (Mike Bell) and the EPA/ORD (Jesse Bash/John Walker) assesses differences in critical load exceedances based on the scale at which deposition is modeled. Phase I of this project will use land-use specific dry deposition estimates at a 500m scale developed for the Chesapeake Bay to assess changes to critical loads exceedances at Shenandoah National Park and the Otter Creek Wilderness. Exceedances will be compared to CMAQ and TDep total N estimates. Additional case study sites have been identified and will be evaluated in 2022.

This research project will address research gaps presented in the TDep Reactive Nitrogen deposition White paper (see sections 3.2.4).

- **Analysis of metals on nanoparticles from Urban deposition sites (NUANC) (CityDep workgroup)**

James Ranville (Colorado School of Mines) and his students, Aaron Goodman, and Carmen Villarruel are analyzing the metals on nanoparticles obtained from NUANC site samples, especially from CO86. They

will be conducting research on the Marshall Fire that destroyed 1,000 homes in a suburban community only a few kilometers from CO86 in 2021.

This research project will address research gaps presented in the TDep Reactive Nitrogen deposition White paper (see section 3.1.1.4) in understanding deposition to urban areas and developing source apportionment methods (see section 3.3.1).

- **Modeling 15N-NH3 stable isotope data to identify Urban Ammonia Sources (CityDep Workgroup)**

Dave Felix (Texas A&M Univ.) is preparing a paper on urban ammonia sources in Denver by modeling 15N-NH3 stable isotope data obtained at the NUANC sites during 2018. The paper is expected to be in review during summer 2022.

This paper will address research gaps presented in the TDep Reactive Nitrogen deposition White paper (see section 3.1.1.4) in understanding deposition to urban areas and developing source apportionment methods (see section 3.3.1).

- **Investigation of phosphorus (P) contributions from urban sources (Pamela Templer; CityDep workgroup)**

Pamela Templer is guiding an undergraduate study at Boston University to investigate phosphorous (P) contributions from urban sources.

- **Dry Deposition of P at NADP sites using samples collected with Aerochem Metrics Dry Side Inserts (DSIs) (Janice Brahney; CityDep Workgroup)**

A project led by Janice Brahney (Utah State University) investigating dry deposition of P at NADP sites using samples collected with Aerochem Metrics Dry Side Inserts (DSIs) recently invented by the group.

Outlook for 2022 research and products motivated by TDep mission

- **Incorporation of CMAQ wet deposition data into the TDep MMF model (Measurement Model Fusion Workgroup)**
- **Peer-reviewed manuscript describing the modernized TDep Measurement Model Fusion model and evaluation of results with the archived model (Measurement Model Fusion Workgroup)**

This manuscript will compare: 1) the modernized (2021.01) with the archived (2018.02) TDep MMF model using the same 2010 input dataset to quantify the differences due to the method changes; 2) the TDep 2021.01 model using the 2010 EQUATES dataset with the same model using the old 2010 ECODEP dataset to quantify differences due to the input modeled dataset; and 3) the TDep 2021.01 model using the 2010 EQUATES dataset with the TDep (2018.02) dataset with the old 2010 ECODEP dataset to quantify the overall difference between the new methods. This will build on the results presented by Greg Beachley at the 2021 Fall NADP Science Symposium.

Project Ideas for the future

- **Incorporation of measurement data from intensive studies (e.g Urban measurements) into TDep MMF model estimates (Measurement Model Fusion Workgroup)**

Initial ideas for inclusion of NO_2 data from SLAMS, measurements of passive NH_3 in the Greeley, CO area, throughfall measurements (including Duke Forest), and deposition in urban areas.

- **Quantify the radius of influence of urban air pollution on interpolated wet-deposition spatial data products (CityDep and Measurement Model Fusion Workgroup)**

Recent TDep Publications (submitted or published since 2021)

Published:

- Fu, J.S., Carmichael, G.R., Dentener, F., Aas, W., Andersson, C., Barrie, L.A., Cole, A., Galy-Lacaux, C., Geddes, J., Itahashi, S., Kanakidou, M., Labrador, L., Paulot, F., Schwede, D., Tan, J., Vet, R. 2022. Improving Estimates of Sulfur, Nitrogen, and Ozone Total Deposition through Multi-Model and Measurement-Model Fusion Approaches. Environ. Sci. Technol. 56 (4), 2134–2142. https://doi.org/10.1021/acs.est.1c05929
- Wetherbee, G., Wieczorek, M., Robertson, D., Saad, D., Novick, J., and Mast, M.A., 2022, *Estimating urban air pollution contribution to South Platte River nitrogen loads with National Atmospheric Deposition Program data and SPARROW model*, J. Env. Manage. 301, 113861. https://www.sciencedirect.com/science/article/pii/S030147972101923X?via%3Dihub.

In review:

- Wetherbee, G.A., in Review, *Atmospheric Deposition of Inorganic Nitrogen at the Rocky Flats National Wildlife Refuge, 2017 – 2019*.
- Heindel, Ruth C., Murphy, Shelia F., Repert, Deborah A., Wetherbee, Gregory A., Liethen, Alexander, E., Clow, David W. (in revision). *Elevated Nitrogen Deposition to Wildfire-Prone Forests Adjacent to Urban and Agricultural Areas, Colorado Front Range, USA*. Earth's Future.