Basic Information

- **Project No. and Title:** NRSP3 : The National Atmospheric Deposition Program (NADP)
- **Period Covered:** 11/01/2018 to 10/31/2019
- **Date of Report:** 03/02/2020
- **Annual Meeting Dates:** 11/04/2019 to 11/08/2019

Participants

An attendee listing for our Fall Meeting and Science Symposium (FY19) is available at our meetings page (http://nadp.slh.wisc.edu/conf/). The fall meeting had 152 registered participants.

Brief Summary of Minutes of Annual Meeting

The NADP is comprised of a technical committee (all participants), an executive committee, several scientific committees, and a series of subcommittees focusing on specific areas of the ongoing project, including operations, quality assurance, critical loads and total deposition, outreach, and data management. All approved meeting minutes from our FY19 Spring and FY2019 Fall Meetings (and all other meetings) are available on the website (http://nadp.slh.wisc.edu/committees/minutes.aspx). Posting of committee minutes is controlled by each committee chair; some subcommittee minutes may be delayed for approval.

Accomplishments

The National Research Support Project – No. 3 (NRSP3) provides a framework for cooperation among State Agricultural Experiment Stations (SAES), the U.S. Department of Agriculture-National Institute of Food and Agriculture, and other cooperating governmental and non-governmental organizations that support the National Atmospheric Deposition Program (NADP). The NADP provides quality-assured data and information on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, base cations, and mercury in precipitation and through dry deposition of several of these compounds. NADP data support informed decisions on air quality and ecosystem impacts related to precipitation chemistry and wet and dry deposition.

Specifically, researchers use NADP data to investigate the impacts of atmospheric deposition on the productivity of managed and natural ecosystems; the chemistry of estuarine, surface, and ground waters; and the biodiversity in forests, shrubs,

grasslands, deserts, and alpine vegetation. These research activities address the mission of the NRSPs of "development of … support activities (e.g., collect, assemble, store, and distribute materials, resources and information)… to accomplish high priority research". Researchers also use NADP mercury networks and data to examine the effect of atmospheric deposition on the mercury content of fish, and to better understand the link between environmental and dietary mercury and human health. This fits with an agriculture research priority of food safety.

At the end of September 2019, NADP supported sample collection in all of the US States, Puerto Rico, the Virgin Islands, and Canada, and conducted scientific outreach and monitoring support in Mexico, and countries in Southeast Asia. Operational support included 262 NTN, 98 MDN, 5 AirMoN (Discontinued operation in October 2019), 18 AMNet, and 104 AMoN locations across North America. Samples are collected to support continued research of atmospheric transport, ecosystem impacts, documentation of spatial and temporal trends, assessment of air pollution mitigation success, development of computer simulations, and for community and educational outreach.

The NTN provides the only long-term nationwide record of base ion wet deposition in the United States. Sample analysis includes free acidity (H^+ as pH), specific conductance, and concentration and deposition measurements for calcium, magnesium, sodium, potassium, sulfate, nitrate, chloride, and ammonium. Bromide has been recently removed due to concerns associated with data quality. NADP also measures orthophosphate ions in the inorganic form, but only for quality assurance, as an indicator of potential sample contamination. Currently, 48 NTN sites are operated at or near SAES, and an additional 13 have been associated with the SAES in the past. In addition, there are quality assurance and testing sites located in Colorado and Wisconsin. The AIRMoN has recently been discontinued; however in the past, it was an important contributor to research of atmospheric transport and removal of air pollutants and the development of computer models of these processes. The MDN offers the only long-term and routine measurements of mercury in North American precipitation. Measurements of total mercury concentration and deposition (and optional methyl-mercury) are used to quantify mercury deposition to water bodies, some of which have fish and wildlife mercury consumption advisories and in the future may be used to meet the Minamata Convention monitoring requirements.

The NADP operates two gaseous atmospheric chemistry networks: the Atmospheric Mercury Network (AMNet) and the Ammonia Monitoring Network (AMoN). The goal of these networks is to provide atmospheric concentrations of mercury and ammonia, respectively, to estimate the rate of dry deposition (without precipitation) and to

support the measurements required to understand atmospheric chemical processing and total deposition of nutrients and pollutants. In many cases, dry deposition could exceed the wet deposition of the same compound, thus, these are key parameters to understand ecosystem impacts. Through the reporting period ending in September 2019, eighteen AMNet sites were collecting five-minute measurements of gaseous elemental mercury and (for a subset of sites) two-hourly average concentrations of gaseous oxidized mercury and particulate bound mercury. The AMNet provides the only long-term region-wide record of basic atmospheric mercury concentrations in the United States. The AMoN measures two-week average concentrations of atmospheric ammonia using passive sample cartridges. This low-cost network is designed to provide spatial and temporal estimates of ammonia in the atmosphere. These data are particularly important to the agricultural community, since many sources of ammonia are related to agricultural processes. In addition, gaseous ammonia deposition contributes to the total nitrogen deposition, an important parameter for understanding agricultural systems. In recent years the AMoN has been the fasting growing NADP network due to the interest of researchers and policy makers in ammonia in the environment. Data from both gaseous networks support continued research of atmospheric transport and removal through dry deposition, and the development of computer models of these processes.

Within this NRSP, there are three primary goals: 1) management and coordination of the NADP monitoring networks; 2) site support, chemical analysis, data validation, and data reporting for network sites; and 3) quality assurance and quality control (QA/QC) activities to ensure consistent operation and standard operational procedures, resulting in the highest data quality possible. During the performance period, all three of these goals were met. The major accomplishment of the NADP is the smooth and consistent operation of the monitoring networks. Operation, maintenance, management, quality assurance, and data distribution from these networks is the major outcome of this grant and project.

The principal output or deliverable from the NADP's networks is the database of precipitation chemistry and deposition rates, along with atmospheric gaseous concentrations intended for the development of dry deposition fluxes (AMoN, AMNet). This database is available free to users on the NADP website (http://nadp.slh.wisc.edu/data/). The wet deposition database has nearly 570,000 NTN, MDN, and AIRMoN observations available for download.

Additional notable outcomes during the project period are as follows:

The NADP CAL determined that web-published bromide data from January 2012 through June 2018 have a known or suspected bias caused by the presence of oxalate in the precipitation. Motions to remove these data from the NADP website and discontinue bromide as an official NADP analyte (due to >80% non-detects) were presented to the NADP Executive Committee on May 17, 2019 and were approved. The data was officially removed from the website in October 2019 and can be accessible through special request to the program office. In November 2018, the NADP Executive Committee passed a motion to move the Hg Analytical Laboratory (HAL) from its longtime home at Eurofins Frontier Global Sciences, Inc., in Bothell, Washington, to the WSLH. This transition was completed in June 2019.

Future Work/Directions:

The WSLH has developed a plan to implement strategic planning meeting during the NADP Spring meetings. The goal is to identify and address the needs of NADP stakeholders, supporters, and data users. Some suggested ideas to be discussed include: future deployments of sensor technology, development of improved data products for users, identifying future analytes of concern, and identify the infrastructure and coordination needs of NADP to support and expand external research. During the fall meeting in Boulder, strategic planning continued and a draft plan will be presented to the NADP community at the Spring 2020 meeting.

The PO is actively developing a NADP supersite on the UW-Madison campus. The site will support collaborations with NADP data users such as the College of Engineering, the College of Agricultural and Life Sciences, Department of Limnology, and the Department of Atmospheric and Oceanic Sciences. The goal is to expand the research opportunity and application for NADP data and infrastructure. Sampler base supports and electrical connections are planned for installation during the spring of 2020.

Impacts

1. Samples Collected: NADP's principal objective and accomplishment/outcome is the collection, analysis quality assurance review, and reporting of precipitation chemistry for sites located throughout North America. In 2018 and 2019, there were 25,000 precipitation samples collected and analyzed in the NTN (not including QA samples) at the 262 network sites. Results are reported as mass concentrations and wet deposition fluxes for each analyte. Over 1,400 precipitation samples from the AIRMoN were analyzed for the same analytes. The AMoN quantified over 5,000 gaseous ammonia samples and the MDN quantified 9,500 total mercury samples. The AMNet measured approximately

125,000 hourly and two-hourly ambient mercury fraction concentrations. All data are available on the NADP website, and were summarized in annual maps and figures.

2. The NADP offers a full technical support to data users and site operators. The program has direct access to technical experts, via the web and toll free numbers) to address site operators questions and offer technical expertise on data interpretation and the outreach materials. Through the NADP Program Office (PO) thousands of inquiries are answered each year. The NADP experts also contribute to the broader scientific community through dissemination of program information at external conferences, meetings, and in peer reviewed publications.
3. NADP Database: Facilitating data access and availability is a key accomplishment/outcome of NADP, allowing support of continued research and outreach. Scientists, policymakers, educators, students, and others are encouraged to access data at no charge from the NADP website (nadp.slh.wisc.edu). This website offers online retrieval of individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports, manuals, and other data and information about the program. The NTN database is now populated by 470,000 observations of precipitation chemistry for all sites and all years. As of today, the 2018 calendar year data are complete and online, and the 2019 data are posted through July, with final QA to be completed in the next few months (final data QA is completed after the full year of data is available). Internet disbursement of precipitation chemistry and atmospheric data is the primary route of dissemination for the NADP project. Website usage statistics provide evidence that our data are being actively used. During the 2018 and 2019 years, NADP estimated annually 23,000 comma-delineated data sets were downloaded, including 14,000 from the NTN database. In addition, approximately 57,000 PDF map images and 100,000 map data sets (grid and kmz) were downloaded.
4. Map Summary: The 2017 and 2018 annual map series of atmospheric concentrations, wet deposition fluxes, and summary report was developed during the fall of 2018 and 2019. The summaries are finalized and printed in October prior to the Fall Science Symposium. For each summary and calendar year, the NADP produces a series of 23 national maps of wet deposition concentration and flux maps for all of our analytes, and summary figures for each of the gaseous networks. These maps are used widely and are one of the major network products. Individual maps are filed by network, year, and constituent, and can be downloaded in several formats (http://nadp.slh.wisc.edu/data/annualmaps.aspx). Individual maps are compiled into Annual Map Summary reports, and the summaries are available for

download (nadp.slh.wisc.edu/lib/dataReports.aspx). NADP program office printed 2000 copies of the 2017 and 2018 Annual Summary, and distributed them to stakeholders and supporters.

5. Fall Scientific Meeting (FY2018 & 2019): At the end of each federal year, a combined business and scientific meeting is held to showcase some of the latest deposition research that occurred during the year. Additionally, during each spring, a 3 day business meeting is conducted. The NADP hosted and organized four meetings in 2018 and 2019. The Fall Scientific Symposium meetings were held in Albany, NY and Boulder, CO in 2018 and 2019, respectively. Both meetings had attendance of over 150 participants and highlighted research that utilizes NADP resources and data. Note, the 2019 Boulder meeting occurred after the performance period, but was organized and emphasized outcomes from 2018 and 2019. The meetings are attended by a diverse group of participants from NIFA, EPA, USGS, Park Service, Forest Service, Fish & Wildlife, BLM, NOAA, states, and tribes. In addition, meetings include representatives from industry, research institutions, educators, and international data users and university researchers. In order to advance the outreach to these groups, the NADP has expanded technical outreach and training to include workshops and work group meetings. In 2018 and 2019, NADP offered a TDEP workshop 'Connecting Stakeholder and Science Perspectives to Better Understand the Linkages Between Agriculture and Reactive Nitrogen Deposition' which was attended by over 100 participants and held Mercury in the Environment and Links to Deposition (MELD) meetings to bring in new stakeholders to guide NADP's efforts in Hg monitoring and reporting.
6. The NADP spring business and operational meetings (Technical Committee, subcommittees, Executive Committee) were held in Milwaukee, WI and Madison, WI in 2018 and 2019. The meetings had attendance of over 60 NADP participants including representatives from NIFA, EPA, USGS, Park Service, Forest Service, Fish & Wildlife, BLM, NOAA, states, and tribes. The meetings are attended by a diverse group of participants including industry representative, researchers, educators, international researchers, and policy makers. In 2019, these meetings included a poster session that brought UW-Madison researchers and NADP stakeholders together to advance cooperation between these expansive scientific communities.
7. During the project period, NADP established a strategic planning group which will draft a programmatic strategic plan; drafts will be available in early 2020 for community input. NADP representatives have presented and exhibited at numerous national and global conferences during the project period. Finally, in 2019, NADP established a new Education and Outreach Subcommittee (EOS) with a mission to coordinate outreach and education activities among the

networks and scientific subcommittees; EOS will provide guidance for outreach efforts and educational materials to the Program Office and Executive Committee. NADP had representation at numerous national and global conferences. The NADP has prioritized outreach that supports bringing in new stakeholders to NADP, these include giving talks and trainings with university researchers (e.g. Consortium of Universities for the Advancement of Hydrologic Science, Inc., National Ecological Observatory Network, Water@UW-Madison), tribal organizations (e.g. Tribal Forum on Air Quality, EPA Region 5 Tribal Environmental Management), and international groups (e.g. International Conference on Mercury as a Global Pollutant, Acid Deposition Monitoring Network in East Asia).

Publications

The following examples of agricultural-related publications and were published during the year in 2019. The publications may extend before and beyond the project period of October 2018 - September 2019. These publications represent a small subset of the total research activities that utilizes NADP data and infrastructure. The full associated publication bibliography is avaible on the NADP web site.

Chang, Y. et al. Assessing contributions of agricultural and nonagricultural emissions to atmospheric ammonia in a Chinese megacity. Environmental science & technology, v. 53, n. 4, p. 1822-1833, 2019. ISSN 0013-936X.

Hember, R. A. Spatially and temporally continuous estimates of annual total nitrogen deposition over North America, 1860–2013. Data in brief, v. 17, p. 134-140, 2018. ISSN 2352-3409.

Jeong, H.; Pittelkow, C. M.; Bhattarai, R. Simulated responses of tile-drained agricultural systems to recent changes in ambient atmospheric gradients. Agricultural systems, v. 168, p. 48-55, 2019. ISSN 0308-521X.

Khan, M. S.; Koizumi, N.; Olds, J. L. Biofixation of atmospheric nitrogen in the context of world staple crop production: Policy perspectives. Science of the Total Environment, p. 134945, 2019a. ISSN 0048-9697.

Koskelo, A. I. et al. Biogeochemical storm response in agricultural watersheds of the Choptank River Basin, Delmarva Peninsula, USA. Biogeochemistry, v. 139, n. 3, p. 215-239, 2018. ISSN 0168-2563.

Ludwikowski, J. J.; Peterson, E. W. Transport and fate of chloride from road salt within a mixed urban and agricultural watershed in Illinois (USA): assessing the influence of chloride application rates. Hydrogeology Journal, v. 26, n. 4, p. 1123-1135, 2018. ISSN 1431-2174.

Sosa Echeverria, R. et al. Sulfur and nitrogen compounds in wet atmospheric deposition on the coast of the Gulf of Mexico from 2003 to 2015. Science of the Total Environment, v. 700, p. 134419, 2020/01/15/ 2020. ISSN 0048-9697.

Select Science Fall Symposium Presentations

During the fall meeting in Boulder, 37 talks and 41 posters were presented. These represent the full diversity of NADPs research and outreach efforts and included international presenters from Canada, Mexico, South Korea, China, and India. A select set of presentations are highlighted below, submitted abstracts highlighted below may have been edited for content and brevity:

The patterns of emissions and depositions of selected air pollutants in China during 2005-2018

Xi Mengxiao, Yu Zhao, Xuejun Liu, Qiang Zhang, Yuepeng Pan, Yang Liu and Lei Zhang: The paper presented the pattern of long-term SO_4^{2-}, NH_4^+ and NO_3^- bulk deposition along with the SO_2,NH_3 and NO_X emission in China from 2005 to 2018. The Generalized Additive Models (GAMs) were constructed to predict the decadal bulk deposition of sulfate, ammonia and nitrogen, through the integration of satellite columns, $PM_{2.5}$ concentration, land-use information and meteorology variables.

Trends in Wet Deposition of Organic Nitrogen in the Rocky Mountains. Katherine Benedict, Bret A. Schichtel and Jeffrey L. Collett Jr. In this study the seasonal and annual variations of organic nitrogen at Rocky Mountain National Park from measurements made between March to October from 2008 to 2019 was investigated. This record of data using the sample measurement and collection techniques provides a unique look at wet organic nitrogen deposition in a sensitive ecosystem.

Patterns of atmospheric and soil mercury in the conterminous U.S. Charles Driscoll, Connor Olson, Benjamin Geyman, Elsie Sunderland, David Krabbenhoft and Michael Tate. This study summarized (i) temporal trends and spatial patterns of mercury emissions, (ii) atmospheric concentrations of mercury species and wet mercury deposition, and (iii) spatial patterns of soil mercury in the conterminous U.S. Observations of atmospheric chemistry were obtained from the Atmospheric Mercury Network (AMNet) and wet deposition data were obtained from the Mercury Deposition Network (MDN) of the

NADP. Concentrations of surface soil mercury were generally highest in the East, coinciding with higher concentrations of soil organic matter and an abundance of forest cover, and generally lower in the West except for elevated concentrations in lands adjacent to the Pacific coast. Forested lands generally exhibited the highest mercury concentrations in surface soils, followed by developed lands, planted/cultivated lands, herbaceous uplands, shrublands, and barren lands.

Chronic and Episodic Acidification of Streams along the Appalachian Trail Corridor, eastern United State. Douglas A Burns, Todd C. McDonnell, Karen C. Rice, Gregory B. Lawrence and Timothy J. Sullivan. The study evaluated stream acidification in 269 headwaters along the Appalachian Trail (AT) across the eastern U.S. The AT is an ideal study region because it transits several eco-regions, is located downwind of high levels of S and N emission sources and includes heterogeneous soils and geology. Chronic acidification at low flow was substantial as 16% of streams had a mean acid-neutralizing capacity (ANC)

A 40 Site Network for Passive Ammonia Measurements along northern Utah's Wasatch Front: Winter and Summer 2019. Randy Martin , Kerry Kelly, Jaron Hansen, Nancy Daher and Christopher Pennell. The Wasatch Front is considered a series non-attainment area for $PM_{2.5}$. Several studies, most recently the 2017 Utah Winter Fine Particulate Study (UWFPS), have pointed out that although the local airsheds appear to be slightly ammonia-rich in regards to NH_4NO_3 formation. There are times, especially during extended persistent cold-pool, capping events (inversions) in which the atmosphere switches to a more ammonia-limited regime. A study was initiated for the winter and summer of 2019 in which a dense network (40 sites) of Ogawa passive NH_3 samplers were deployed from Brigham City to Mona, UT, approximately 140 miles, which include the population centers of Ogden, Salt Lake City and Provo. The winter study took place from mid-January to mid-February and the summer study extended from mid-July to mid-August. Preliminary analysis showed the average winter NH_3 concentrations (≈5-10 ppb) were lower than the average summer values (20-30 ppb), with notable difference between the Salt Lake and Utah county airshed.

Evaluation of the Efficacy of the National Atmospheric Deposition Program (NADP) National Trends Network (NTN) for Assessment of PFAS Deposition in Precipitation. Martin Shafer, Mark Olson, Camille Danielson and Kirsten Widmayer. This pilot study investigated the efficacy of the NADP precipitation samples for PFAS deposition determination and provides new data on levels of PFAS in precipitation across the US. PFAS measurements were performed on geographically diverse precipitation samples from the NADP National Trends Network (NTN) and in parallel conducted laboratory and field experiments designed to examine whether the NTN as currently configured would

support using the large network of 255 sites as a national PFAS sampling network. Concentrations of the detectable PFAS species were low, generally less than 1 ng/L, though the sum of the quantified species exceeded 4 ng/L at many sites. The carboxylic acid species were by far the most frequently detected, with PFHxA, PFHpA, PFOA and PFNA each present in nearly 70% of all samples. Shorter-chain PFAS compounds dominated, with no PFAS compounds with carbon numbers greater than nine detected. Sites from the Mid-Atlantic States generally had the greatest number of detectable PFAS species and highest concentrations.

Posters:

Experimentally derived nitrogen critical loads for northern Great Plains vegetation. Amy Symstad, Anine T. Smith, Wesley E. Newton and Alan K. Knapp. The critical load concept facilitates communication between scientists and policy makers and land managers by translating the complex effects of air pollution on ecosystems into unambiguous numbers that can be used to inform air quality targets. Anthropogenic atmospheric nitrogen (N) deposition adversely affects a variety of ecosystems, but the information used to derive critical loads for North American ecosystems is sparse and often based on experiments investigating N loads substantially higher than current or expected atmospheric deposition. In a four-year field experiment in the northern Great Plains (NGP), where current N deposition levels range from ~3 to 9 kg N/ ha/y, we added 12 levels of N, from 2.5 to 100 kg N/ha/y, to three sites spanning a range of soil fertility and productivity. Our results suggest a conservative critical load of 4 to 6 kg N/ ha/y for the most sensitive vegetation type we investigated – Badlands sparse vegetation, a community that supports plant species adapted to low fertility conditions – for which N addition at this rate increased productivity and litter load. In contrast, for the two more productive vegetation types characteristic of most NGP grasslands, a critical load of 6 to 10 kg N/ha/y was identified. For these vegetation types, N addition at this level altered plant tissue chemistry and increased non-native species. These critical loads are below the currently suggested range of 10 to 25 kg N/ha/y for NGP vegetation and within the range of current or near-future deposition, suggesting that N deposition may already be inducing fundamental changes in NGP ecosystems.

Cloud and Fog Deposition: Monitoring in High Elevation and Coastal Ecosystems. The Past, Present and Future. Selma Isil, Jeffrey L. Collett, Jr., Peter Weiss-Penzias3, Christopher Rogers and Jason Lynch. Deposition of pollutants by cloud water exceeds deposition by precipitation and dry deposition in high elevation settings. The large loading of pollutants in such environments is due to a combination of factors such as high frequency of cloud immersion, high wind speeds, orographic enhancement of precipitation, and large leaf area of tree species typical in these environments. Fog

impacted coastal ecosystems also experience higher pollutant loadings similar to cloud impacted high elevation sites. Therefore, development of meaningful critical load values and total nitrogen budgets for high elevation and fog impacted sites requires reliable cloud and fog water deposition estimates. However, the cost and labor intensity of cloud water sample collection have made it difficult to conduct long-term studies that would provide the data needed to develop accurate estimates. Current understanding of fog formation, transport, and the role of fog in hydrogeological and biogeochemical cycles is incomplete due, in part, to lack of a concerted interdisciplinary approach to the problem. Historically, these obstacles have limited collection of cloud and fog water samples. Summary results from a small cloud water monitoring network that operated in the Appalachian range from the mid-nineties through 2011, as well as a qualitative review of other cloud and fog water studies conducted in the United States, Europe, South America/Pacific, and Asia will be presented. Current research findings and collection methods will also be reviewed. Recent scientific efforts by the NADP's Total Deposition Science Committee and NADP's Critical Loads of Atmospheric Deposition Science Committee have identified occult deposition as a "need" in developing critical loads for ecosystems that experience significant cloud and fog impaction.

Determining adequate levels of nitrogen and sulfur deposition to prevent harmful tree species level decreases. Justin Coughlin, Christopher M. Clark, Robert Sabo, Jeremy Ash, Jennifer James, Travis J. Smith and Linda Pardo. Ecosystems in the United States have experienced extensive nitrogen and sulfur deposition decreases over the last thirty years resulting in lower levels of acidic rain, lessening eutrophication, and declining soil acidification. As nitrogen and sulfur deposition continue to decrease, policy frameworks can be established to determine adequate levels of deposition to protect species diversity and abundance. Recent advances in quantifiable deposition effects on individual tree species in the contiguous United States (CONUS) have presented novel data on the growth and survival rates of 94 different tree species including new critical load information. Using the most current NADP total nitrogen and sulfur deposition (dry + wet) surfaces, the United States Forest Service's live tree basal area surfaces, and the newly available tree species response curves, we have generated forest-level rasters showing the net (negative and positive) effects on tree species across the CONUS from 2014-2016 averaged total nitrogen and sulfur deposition. In addition, deposition magnitude CONUS rasters have been modeled to determine levels that would ensure forest growth and survival rates do not exceed 5 and 1%, respectively. This pertinent information can be used in policy decisions to ascertain appropriate ambient level concentrations of NOx and SOx ensuring forests are not adversely harmed.

An investigation into the importance of amine compounds to organic nitrogen in aerosol. Evelyn Bangs, Katherine B. Benedict, Amy P. Sullivan and Jeffrey L. Collett Jr. In Northeastern Colorado agriculture is an importance source of atmospheric nitrogen compounds, specifically and most commonly studied is ammonia. However, amines are also emitted from a variety of agricultural activities but few studies have focused on these organic nitrogen compounds and the processes that these compounds will undergo to form particulate matter. A set of samples from the spring of 2019 (April) were collected using URG denuder/filter-pack sampling in the following Colorado locations: Greeley, Fort Collins, and in Rocky Mountain National Park (RMNP). These samples were analyzed for a suite of amine compounds, inorganic ions, and total nitrogen (TN). Additionally a Micro-Orfice Uniform Impactor Depositor (MOUDI) was operated at the Fort Collins site to collect highly resolved size distribution data was collected for the summer and winter seasons. The MOUDI samples were analyzed for inorganic ions, amines, and organic acids to assess the processes that were forming amine particulate. While 16 different amines were analyzed, there were several that were observed below the detection limit. The amines that were observed in higher concentrations included methylamine, dimethylamine, trimethylamine, tert-butylamine, sec-butylamine, isobutylamine, and amylamine. In this study we will examine the contribution of amines to total organic nitrogen and the inorganic nitrogen species measured. We will also investigate the size distribution of the various measured species to better understand aerosol formation processes in the region. Amines were generally greatest in concentration at the Greeley site and smallest in concentration at the RMNP site, as we expected due to proximity of sources.

Agricultural Ammonia Monitoring. Sung-Chang Hong, Sae-Nun Song, Kyeong-Sik Kim, Sun-Young Yu and Gyu-Hyeon Lee. Ammonia (NH3) generated from the agricultural sector is known as a precursor to fine particulate matter. Fine particulate matter (PM2.5) which is secondarily generated is more dangerous to human bodies than particulate matter (PM10) and it is generated in the air by chemical reaction with various substances such as nitrogen oxides (NOx) and sulfur oxides (SOx). There are various research results which say that the most effective method to reduce fine particulate matter is to control ammonia. Therefore, it is necessary to monitor the amount of ammonia generated in the agricultural sector. Accordingly, we are planning to establish a long-term monitoring system for ammonia and air pollutants in agricultural areas. The ammonia and air pollutant observatory site is planning to select and install monitoring systems focusing on large-scale agricultural areas in the paddy area, upland crop area, cultivation under structure area, and fruit tree growing area. The samples are to be collected from atmospheric dry samples, wet samples, PM10, and PM2.5. The major analytical items are ammonium ion (dry and wet) and gaseous ammonia (passive atmospheric sampling). From this year on, we are conducting research projects which

are developing of the emission inventory of ammonia for paddy rice, upland crops and plastic house cultivation crops. Crop land sector needs to enhance, to newly develop emission factors by crop, cultivation method, nutrient input material (urea fertilizer, cow manure compost, pig manure compost and poultry manure compost), application time, and cultivation environments in Korea. The status and characteristics of ammonia emission by major crop cultivation areas in the agricultural sector will be analyzed and the characteristics of ammonia and air pollutant emissions in the agricultural area with the national atmospheric ammonia concentration, urban air pollution observation network, and emission characteristics of atmospheric pollutants will be compared.

An Integrated N Cycling Approach with Agriculture, Atmosphere, and Hydrology Models. Limei Ran1, Yongping Yuan, Jonathan Pleim, Rohit Mathur, Ruoyu Wang, Dongmei Yang, Wenlong *Liu7*, Verel Benson, Ellen Cooter and Jimmy Williams. The poster presented an integrated modeling system (IMS) with agriculture (EPIC - Environmental Policy Integrated Climate), atmosphere (WRF/CMAQ - Weather Research and Forecast model and Community Multiscale Air Quality), and hydrology (SWAT - Soil and Water Assessment Tool) models to assess the interactions among land-air-water processes. The centerpiece of the IMS is the Fertilizer Emission Scenario Tool for CMAQ (FEST-C) which includes a Java-based interface and EPIC adapted to regional applications along with built-in database and tools. The Linux-based interface guides users through EPIC simulations for any CMAQ grid domain over the conterminous United States (CONUS) and integration among the multimedia models. This presentation focuses on the description of the currently released FEST-C and the impact assessment of agricultural fertilization on air quality through an improved CMAQ bi-directional ammonia approach. As N deposition is also an important source altering N cycling, the influence of nitrogen deposition along with weather variability on cultivated soil N budget will also be examined for CONUS. The system is applied over CONUS with a 12km resolution for 2010, 2011, and 2012. EPIC simulations are conducted using WRF/CMAQ weather and N deposition for these years and cases adjusted to represent conditions in the early 1990s for assessing the impacts of N deposition reduction since 1990 due to tightened NOX emission standards under the Clean Air Act (CAA). SWAT integrated with EPIC and WRF/CMAQ are then applied to the Mississippi River Basin (MRB) to simulate watershed hydrology and water quality for these years under different N deposition conditions. Preliminary results demonstrate that air quality linked with simulated agriculture improves NH3 flux estimation and results in better performance for N cycling in the atmosphere. The N budget in agricultural production is sensitive to weather variability and atmospheric N deposition with increased N fertilization and decreased N loss in areas with N deposition reduction.