TDEP Committee Meeting, April 14, 2014, Fort Lauderdale, Florida

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1. **Welcome and Introductions**
   Self introductions by all attendees

   Presentations outlined below may be posted on the TDEP web page: http://nadp.sws.uiuc.edu/committees/tdep/ Please refer to the presentations for further information beyond what is provided in these minutes

2. **Summary of TDEP Maps** (Presentation by Donna Schwede and Gary Lear)

A. Review of the Hybrid approach
- Monitoring data used where available
  - CASTNET, AMoN, SEARCH for air concentrations
  - NTN for wet deposition
- Modeled data from CMAQ (dry deposition only)
  - modeled concentrations fused with measurements to create hybrid grid.

B. Current Status of Maps and Data
- Error found in bias adjustment for 2007-2012; so grids and maps were updated
- Version 2014.01 available on the FTP site
- Schwede and Lear paper describing methodology and results accepted for publication in Atmospheric Environment

C. Some issues with the Maps
- Effects of model resolution
  - Higher resolution model output starting in 2007 shows additional detail of local sources
- Effects of temporal variations in available data
  - AMoN not until 2008
  - New sites coming online may cause artifacts in apparent trends
- Effects of spatially limited data
- Effect of the IDW distances
- Limitation of bias correction surface arising from number of network sites
- Emissions inventory error in 2008 for NC

D. Comparisons with Other Approaches
- Analyses initiated as a result of the comparisons point to additional research areas for understanding deposition processes and for the hybrid methodology
- CMAQ versus TDEP
  - HNO3: CMAQ concentrations are higher than TDEP
  - NH3: impact of AMoN in later years; also some averaging issues like sum of hourly versus weekly values
  - pNO3 and pNH4: size distribution approach in TDEP needs to be improved
  - compensating biases results in total nitrogen dry deposition values that are similar;
  - SO2: TDEP values higher than just CMAQ. Outliers tend to be individual sites and years; Ohio River Valley area has differences with winter and spring having highest bias
- MLM versus TDEP
  - TDEP values higher for HNO3, pNH4, and pNO3; true even at BVL130 which is a corn field

- Vd is a big driver due to differences in model algorithms between CMAQ and MLM as well as differences in meteorological inputs (On-site versus modeled) and differences in site characteristics
- HNO3: aerodynamic resistance (Ra) is the controlling resistance
- For particles, concentrations agree better than depositions pointing to size distribution assumption
- Size characterization is important as it can be very different between the two models
- Vd is again a big driver
- SO2 TDEP values are higher as CMAQ Vd's are much higher
- SO2 cuticular resistance may be important

- Throughfall versus TDEP
  - Different processes are accounted for by the two methods
  - Throughfall might be a lower limit of total deposition
  - Only forested sites were compared to eliminate some of the biases
- Dry to Wet ratios, i.e. two times wet dep
  - TDEP gives a lot more resolution

E. Future Steps
- Characterize uncertainty
- Extend estimates to before 2000
- Incorporate new CMAQ bidi runs
  - 2002-2011
  - Use 12 km for all years
  - Improved NH3
  - Determine how to fuse with AMoN
- Incorporate 1-in-3 networks (IMPROVE, CSN)
  - will require bias correction
  - calculate weekly deposition
- Adjust for autocorrelation
- Use model for particle size distribution instead of 80/20 rule
- Deposition adjustment for mass balance preservation
- Fusion of CMAQ and NTN wet deposition
- Further model evaluation/intercomparison work
- Web page development

F. Long Term Research Suggestions
- Table of projects generated at Fall 2012 NADP Meeting (see presentation)
  - Some good progress made on this table according to Donna
- Gary soliciting input from group for prioritizing future steps
- How to approach characterizing uncertainty?
  - Scheffe: do not go too deep
  - Dennis: go after more process level understanding rather than uncertainty
  - Walker: we can ask why there are differences in different budgets using different methods; investigate uncertainty in one species
- Make TDEP maps go as far as back as start of CASTNET and/or emissions inventory
- Essential to incorporate CMAQ bidi runs
- Jansen: Use all SEARCH data
- Adjusting deposition to preserve mass balance

- Fusion with CMAQ and NTN
  - Using CMAQ wet deposition that has been bias adjusted based on NTN precipitation data
  - TDEP currently giving more weight to measured data
  - investigate the differences in doing it two different ways
- Discussion
  -Rich: How does CMAQ compare with actual measured values?
  -Emily: How does model output compare to GEOCHEM?
  -Robin: TDEP dry dep values are very different than CASTNET values and people need to know why; throughfall also yields different values and these differences need to be further elucidated
  -Gary posed as final question: As these differences are rolled out what would the group like to see as far as documentation that describes the differences in the versions??
    1. Provide a surface of uncertainty so people can see what the values for specific sites are, i.e. what comes from CMAQ, what comes from TDEP?
    2. Can parameters or regions with biggest concerns be identified? Can we give some guidance to user community such as scale of confidence factor?
    3. Change tracking is not provided between versions. Some of the applied changes are documented but the change tracking is not complete and/or can be presented better.
    4. What parameters have changed with respect to core analytes?
    5. Document/describe temporal and spatial changes. Meta data changes are very important.
- Map Locations
  - Easiest to post on EPA website or FTP site.
  - Gary proposing a webpage on the NADP site under TDEP since this is an NADP project
  - Most recent version will be posted with archives of past versions available
  - In conclusion, a web page will be set up and through the NADP site links will be provided to the EPA server

3. **TDEP Communication Piece** (Kristi Morris)
   This will be a two-page fact sheet that stresses the mission of TDEP. Will be composed of
   - Layperson's description of methodology
   - What model estimates are being used, what measurements are being used
   - Why estimates are needed
   - Summary of comparisons and an explanation of the differences
   - Availability of TDEP maps
   - List of caveats
   - Appropriate uses for TDEP maps
   - Limitations?
   - Summary of next steps as this is a dynamic process

4. **Comparison of Parameterizations of the Ra and Implications for Dry Deposition modeling** (Presentation by John Walker)
   - Flux = Vd * Concentration
   - Vd = 1/Ra+Rb+Rc, where Ra is the aerodynamic resistance, Rb is the boundary layer resistance and Rc is the canopy resistance

- HNO3 used as analyte for this exercise since there is no Rc for HNO3
- Ra is a function of wind speed and turbulence
- For unstable and stable conditions, a stability correction must be applied
- Since Ra is a function of wind speed it also needs to be corrected
- Parameterizations of Ra differ with respect to functional dependence on surface layer characteristics, application of stability corrections and form of stability corrections
- The purpose of this study is to quantify the degree to which differences in model-derived dry deposition fluxes are related to use of different Ra parameterizations. The following models will be compared:
  1. CMAQ-WRF
  2. CMAQ-MM5
  3. CAMx
  4. CAPMoN
  5. MLM
- MLM approach assumes that Ra is a function of wind speed and the standard deviation of wind direction
- MLM shows higher Vd at night under neutral and stable conditions
- MLM shows most scatter compared to other models due to use of constant between stable and unstable conditions
- There are larger differences at night for all models
- Next Steps:
  1. Conduct analysis at additional sites (COW137 and HOW191) with different meteorology, surface characteristics and HNO3 concentrations
  2. Extend analysis to compare grid model Ra to point estimates of Ra
  3. Questions: For future work, will John move beyond Ra to Rc for example?
     - Will most likely move on to another gas like SO2 or NO2
     - John also commented that another ultimate goal may be to recommend a common set of parameterizations like the Europeans are doing already

WRAP-UP for Morning Session

- Some additional comments:
  1. CLAD had questions about the data such as where is it, etc.
  2. How to deal with changing deposition estimates and how are past critical load estimates impacted?
  3. David Gay would like to see an index of variability between the estimates, where are they more consistent? Where less?

5. Results from the Nitrogen Flux Workshop (Presentation by John Walker)

Workshop kicked off with a flux session during regular meeting followed by the one-day workshop. Key findings, conclusions, and recommendations from each presentation were summarized and presented by John Walker.

A. Thursday Session:

1. <u>Nitrogen Budgets at Local, Regional and Global Scales.</u> Fowler, Famulari and Smith
   - Presented by the key note speaker David Fowler
   - Presentation was an overview of the European perspective as to where they are with nitrogen budgets, policies, etc.
   - Policy questions: acidification, euthrophication, health and climate
   - Science questions: understanding the fate and effects of emitted N and trends; making models honest

- European N assessment consisted of:
  a. extensive monitoring (EMEP)
  b. extensive modeling and process research
  c. effects: ecological, climate and human health
  d. history of protocol development (UNECE, EU)
- Some conclusions:
  a. N budgets are regularly computed but are of variable quality
  b. monitoring networks are vital for facilitating estimation of budgets but are rarely designed at the outset with this end goal in mind
  c. hot spots are easily missed by measurements and models due to scale and logistic considerations and this leads to underestimates in CL exceedances
- COTAG flux measurements
  a. Consisted of denuders at different heights
  b. Did have an intensive labor demand
  c. High equipment cost
  d. Very few instruments have enough sensitivity to resolve vertical gradient

2. Reactive Oxide Fluxes Above Two Mid-latitude North American Mixed Hardwood Forests. Geddes and Murphy
   - Key findings were:
     a. Downwind receptor regions still receive appreciable NOy inputs from dry deposition
     b. Long term measurements needed to account for variability of deposition at receptor sites
     c. Difficult to separate true 'surface exchange' from within-canopy chemistry
3. NO2 and O3 Deposition to Intensively Managed Grassland. Wolff, Flechard, Spirig, Neftel and Ammann
   - NO2 can be large part of deposition budget
   - Dynamic chamber measurements of NO2 deposition showed large scatter
   - Daytime/nighttime Rc values indicated strong stomatal control of deposition of NO2
   - First parameterization approach for Gc NO2 was successful

B. Flux Workshop

1. Workshop Introduction: Chris Rogers
   - While N is a key nutrient, long-term ecosystem inputs in excess of biosphere demand can lead to changes in vegetation and microbial species composition, decreased resistance of vegetation to stressors
   - Most CL assessments in the US currently rely on deposition budgets that are incomplete (i.e., do not include organics) or contain highly uncertain estimates for important compounds
2. Development of Total Nitrogen Deposition Budgets. Walker, et.al.
   - Methods for developing total N budgets were summarized;
     a. Flux measurements
     b. Models
     c. Combination of measurements and models
     d. Hybrid approach
   - Three case studies were presented for Duke Forest, Rocky Mountain National Park, and the Upper Susquehanna River;
   - Key findings were:
     1. The case studies represented a range of deposition conditions from very low (3.5 kg/ha/year of N) to relatively high (17 kg/ha/year of N);

2. The deposition budget at site with most urban influence was dominated by oxidized compounds while most remote site was dominated by reduced species
3. Deposition of organic N is poorly characterized
4. Even for better understood compounds such as HNO3 differences between in-situ measurements and regional models are still persistent.

3. Reactive Nitrogen Deposition In the United States: The Increasing Importance of Ammonia. Jeff Collett
   - Changes were discussed in reduced versus oxidized nitrogen budgets
   - Deposition budgets for RMNP and the Grand Tetons were summarized and are dominated by reduced N
   - Also presented were long term measurements of NHx-NOx-SOx aerosol gas system in Boulder, WY; air quality in the Bakken Shale Region; pilot IMPROVE NHx network
   - Key Findings and recommendations were:
     a. As NOx emission decrease, NHx is an increasingly important component of N deposition;
     b. AMoN will greatly improve understanding of NH3 dry deposition;
     c. Another approach still needed to characterize NH3 and NH4+ at higher time resolution in order to understand PM formation, validate air quality models, and to attribute source contributions
4. Thoughts on Mechanisms of Oxidized Nitrogen Emission and Deposition. Ron Cohen
   - Global models find mechanistic models of soil emission too large. An Ad Hoc canopy reduction factor introduced for soil emitted NOx in order to deal with this issue
   - Laboratory measurements suggest ecosystems emit NOx directly when ambient concentrations are low
   - Most field instruments for observing N oxides have positive artifacts
   - Key findings were:
     a. In-canopy formation and emission of XPAN is significant
     b. Aerosol RONO is a large fraction of SOA
     c. Combination of satellite based instruments, new in situ approaches and lab measurements are bringing changes to how we approach describing mechanisms of N exchange
5. Continuous Measurements of NOy and NOy Components During the Southeast Atmospheric Study. Eric Edgerton
   - SOAS study attempted to answer several questions regarding the magnitudes, variations, and controlling processes for biosphere-atmosphere fluxes of oxidants and reactive carbon and nitrogen across spatial scales. Also, what chemistry and physics control BVOC oxidation?
   - Measurements of speciated NOy at the Centreville, AL SOAS site were presented
   - Speciation included peroxy nitrates (PN) and alkyl nitrates (AN)
   - Key findings were that additions of ONs and AN brings to near-closure the NOy budget, PNs and ANs likely important at all times of year at both urban and rural sites; and NOy and HNO3 should be measured in regional networks
6. Application of Common and New Techniques for Measuring Air-surface Exchange of Reactive Nitrogen. Ammann and Wolff
   - Flux measurement techniques summarized (eddy covariance, disjunct EC, relaxed eddy accumulation, gradient methods, dynamic and static chambers)

- Key points were:
  a. The choice and application of flux measurement methods depends on many different factors
  b. Each measurement method has advantages as well as limitations;
  c. Model approaches are necessary for spatial upscaling
  d. Physical, biological and chemical processes need to be considered for interpretations and understanding of flux mechanisms
  e. The representativeness of flux measured at a certain height with respect to biosphere-atmosphere surface exchange is uncertain as well as flux divergence due to chemical reactions

7. Constraints on Air Quality Budgets of the Sources and Sinks of Reactive Nitrogen. David Henze
   - Approaches for optimizing NH3 emissions in global transport models were summarized
   - Presentation dealt primarily with receptor oriented approaches using observational datasets to optimize emissions
   - Bidirectional NH3 framework implemented with GEOS-CHEM
   - Future work will constrain bidirectional fluxes based on observations
   - Summary points were that global models are rapidly coming up to the state of science as far as NH3 processes, More bidirectional flux measurements are needed, and AMoN figuring prominently in modeling studies.
8. John Walker's Summary of Nitrogen Workshop
   - Speciated budgets are the goal, but still need a minimum set of measurements for quantifying total N budget. These would be:
     a. Total oxidized dry N flux
     b. Dry NH3 flux
     c. Wet NH4, NO3 and ON
     d. Dry NH4, NO3 and total pON fluxes
   - Additional flux measurements are needed to validate or adapt NH3 cuticular resistance parameterizations and to characterize vegetation NH3 compensation points cross N gradients and land use types
   - Existing Knowledge Gaps and Recommendations are:
     a. To assess the influence of chemistry within the canopy air space on net canopy-scale N fluxes
     b. Further our understanding of factors driving the canopy resistance for gas phase ON compounds
     c. Some important knowledge gaps are specific high elevation sites in complex terrain
     d. Current budgets rely heavily on Vd's and air-surface exchange algorithms that have not been evaluated for many of the environments to which they are being applied
     e. More direct flux measurement are needed for development of N budgets and evaluation of air-surface exchange algorithms. Need to investigate funding opportunities for field campaign across key ecosystems

     f. Develop a routine method for bulk ON in rainfall that takes advantage of NADP infrastructure
     g. Concentrations and flux measurements of ON compounds are needed for improving chemical transport models

h. Low cost flux measurements should be investigated

- Next steps to take are:
  a. Continue discussing sharing of data and potential collaborations
  b. Encourage workshop participants to return to NADP and engage a wider audience of scientists
  c. Hold a special session at AGU with NADP participation
  d. Have another workshop in a few years
- Some points that came up from follow up discussion were that we need to also get with LTER and NEON folks; explore 'hot spots' in more detail and also to take a look at impact of oil and gas development

6. **N and S Flux Measurements in a High Elevation Deciduous Forest in the Southeast United States** (Presentation by John Walker)
   - The site is a high elevation site with existing infrastructure
     - long term Forest Service ecological research site
     - there are also NADP, CASTNET and AMoN measurements being made
     - Ameriflux tower on site as well
   - Investigated how this forest manages carbon and water; turbulence was measured at multiple heights from 40 ft tower
   - Positive vertical advection associated with cold-air drainage
   - Horizontal advection driven by landscape heterogeneity from mid to late AM
   - Flux measurements influenced by topography; 50% of observations need to be filtered out
   - Measurements will consist of:
     a. Canopy scale fluxes of total NOy, O3, NH3, HNO3, HONO, SO2, NH4, NO3, SO4, CO2, H2O, sensible heat, and momentum above a mixed hardwood forest
     b. Wet deposition of NH4, NO3, and total ON
     c. Throughfall fluxes of NH4, NO3, SO4 and total N
     d. Concentrations of N in particulate matter
     e. In-canopy vertical gradients of HNO3, SO2 and NH3
   - Objectives are to:
     a. Calculate N deposition budget for high elevation forest in Southern Appalachia
     b. Parameterization of NH3 flux model for forest ecosystem
     c. Comparison of throughfall and canopy-scale fluxes
     d. Get a better understanding of in-canopy deposition profile
   - Existing needs are:
     a. In-canopy vertical profile measurements of HNO3, NH3, NO2, SO2. Could be done with passive samplers
     b. To characterize spatial variability of air concentrations within surrounding watershed. Will help quantify representativeness of single-point tower measurements
     c. May need support for throughfall measurements
     d. Wondering if isotopic characteristics of N in throughfall would be useful?
     e. No resources to do stream chemistry and would like collaborations for this part
     f. Also need soil concentrations of extractable NH4, pH, Total N canopy biomass, chemistry of solution within stomatal cavity, chemistry of leaf surfaces, wetness throughout canopy, and pH of this moisture level.

7. **Leiming Zhang White Paper** (Group Discussion)
   - Group addressing what to do with the information in the white paper
   - An Ad Hoc committee proposed to review procedures and decide what to do with methodology with respect to TDEP methodology
   - Members proposed for committee were: Seth Lyman, Eric Edgerton, Jesse Bash from EPA/ORD, Donna Schwede, Heather Holmes, Eric Prestbo
   - Mae Gustin has written a response to what is proposed as she has some concerns based on data used and what we may get out of the exercise
   - John Jansen commented that if Leiming's focus is deriving flux at measurement sites his methodology is highly dependent on meteorology. John recommends revisiting getting site-specific meteorology and land use information and to at least do a sensitivity analysis
   - The Ad Hoc committee will report back to the larger community with the committee's specific charge being "We either like this method or we do not." If method not liked, then propose another method or at least identify what exactly the group does not like and figure out replacements.

8. **The Future of TDEP** (Group Discussion led by Gary Lear)
   - Need a longer term vision of where committee is going with TDEP
   - Gary proposed a workshop on monitoring needs as far as total deposition, which direction to take CASTNET, etc.
   - Spring 2015 will be probable time as Fall 2014 is too soon.
   - There will be lead in seminar similar to the N Flux Workshop and one day should be sufficient for all
   - Gary wanted input on other topics besides monitoring in support of total deposition. Some ideas were:
     - Besides monitoring techniques, also discuss how many sites are needed
     - Satellite data and how this could figure into network design and assessment
     - Risk and technology review groups for human health effects are completely separated from the NADP group. Maybe this group should integrate with ours. To this end, we could include an "Other" session to get speakers to come; but Rich Scheffe thinks this effort should be separate from the workshop. However, someone from this group could be invited to do a specific talk;
     - Include more toxics discussions
   - Need to get workshop onto the Spring 2015 Calendar

9. **TDEP Committee Officer Elections**
   It was decided to keep the current officers for another year.

10. **Wrap-up**
    - Some discussion topics/presentations put forth for the Fall 2014 TDEP Committee meeting included isotopes (Emily Elliott), update on the Coweeta work (John Walker), update on the Ra work (Donna Schwede and John Walker), update from the mercury ad hoc committee.
    - Meeting adjourned