Measurements and Modeling to Enhance Estimates of NH_3 Total Deposition

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Outline

- Overview of NADP TDEP Project
- TDEP challenges with respect to NH_3
- Research areas to improve TDEP maps of NH_3
  - Spatial variability study
  - Site characterization study

Total Deposition (TDEP) Project Goals

- Develop the "best" estimate of total deposition for use in critical loads analyses and other ecosystem exposure analyses
- Provide a consistent approach for obtaining deposition values for the US for the years 2000 – present.
- Vet the method and the deposition values within the National Atmospheric Deposition Program (NADP) critical loads (CLAD) and total deposition (TDEP) science committees as well as the general scientific community
- Document the methods used and make available with the data
- Produce maps and ESRI grids of the data and make available on the NADP website
- Update the data and method as the measurements, modeling, and data fusion techniques advance

Overview of the TDEP Approach

1. Interpolate monitoring concentrations where available
2. Fuse measured and modeled concentrations for measured species using a radius of influence for measured species
3. Multiply fused concentrations by modeled deposition velocity (V_d) to get dry deposition
4. Combine deposition grids from Step 3 with modeled dry deposition for unmeasured species
5. Combine dry deposition grids with wet deposition grids to get total deposition

Monitoring Data Sources

Where is AMoN?

Mode	Variable	Data Source AIRMoN	CASTNET	SEARCH	NTN	PRISM	CMAQ
Wet	wNH_4	●			●	●	
	wNO_3	●			●	●	
	wSO_4	●			●	●	
	Ca, Mg, Na, K, Cl	●			●	●	
Dry	pNH_4		●	●			●
	pNO_3		●	●			●
	pSO_4		●	●			●
	pCa, pMg, pNa, pK, pCl		●	●			●
	HNO_3		●	●			●
	NH_3						●
	SO_2		●	●			●
	HONO						●
	N_2O_5						●
	NO						●
	NO_2						●
	NTR						●
	PAN						●
	PANX						●

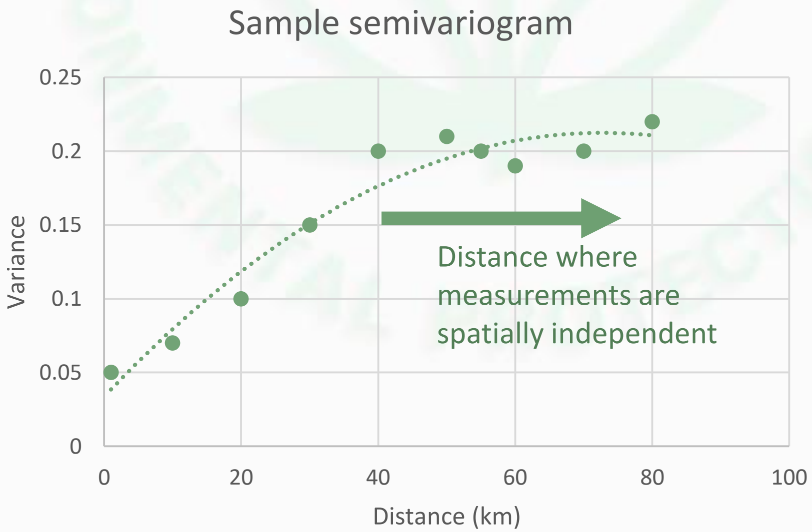
Removed in most recent version as sites have closed.

Challenges of NH_3

- TDEP currently doesn't use AMoN to bias correct NH_3 for the following reasons
  - NH_3 is also highly spatially variable – hard to define the radius of influence
  - NH_3 exchange is modeled in CMAQ as a bidirectional flux – direction of flux depends on the air concentration and the compensation point (Bash presentation)
    - Bias correcting the concentration would break the balance in the bidirectional model and could result in an incorrect flux magnitude and direction
- AMoN is used in CMAQ model development and evaluation

Radius of Influence

- Correlograms are currently used to define the maximum radius of influence for combining observed and modeled data
- For each chemical and season, we plotted the sample variogram of model concentration values and then fitted an exponential covariance model with three parameters (nugget, sill, and range) using a nonlinear least squares algorithm. The covariance model was then normalized and plotted against distance.
- For NH3, this process didn't work well and a spatial variability study was done to explore the radius of influence

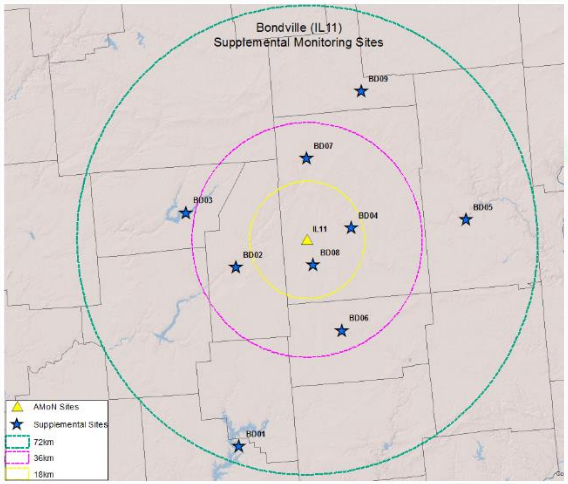


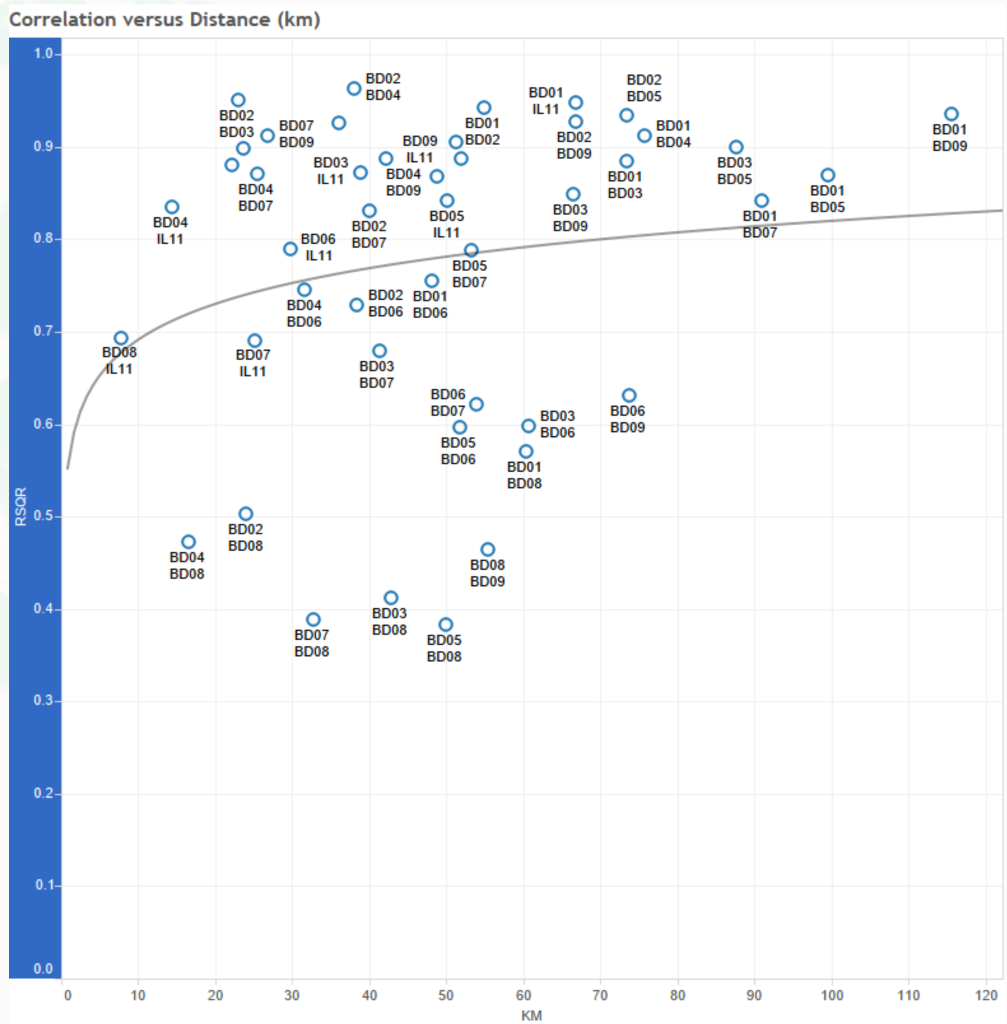
NH_3 Spatial Variability Study

- Perform a geostatistical analysis to calculate a radius of influence for NH_3 that can be applied to the spatial concentration grids used by TDEP
- Passive NH_3 sites were randomly located within 70 km of the Fort Collins, CO and Bondville, IL AMoN sites
  - Sites measured 2-week NH_3 concentrations on a 1:6 week schedule for 1-year
  - Bondville is influenced uniformly by agricultural emissions of NH_3 (crops, fertilizer application) with flat terrain.
  - Fort Collins is influenced by large CAFOs to the east and complex terrain (Rocky Mountain National Park) to the west.
- Data also gathered in North Carolina 2007-2009 for the CAMNet study
  - Sites were influenced by animal operations (hog farms)
- SANDS study provides NH_3 spatial variability information from 5km transect up the Coweeta Basin (2016)
  - Low NH_3 concentrations, forested

NH_3 Spatial Variability Study

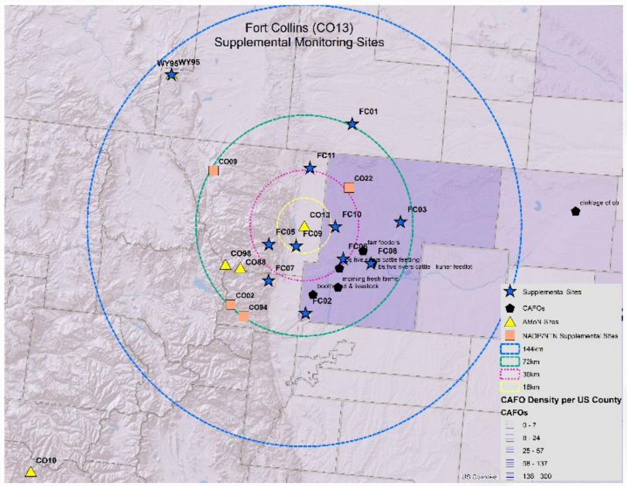
Bondville, IL - Cropland

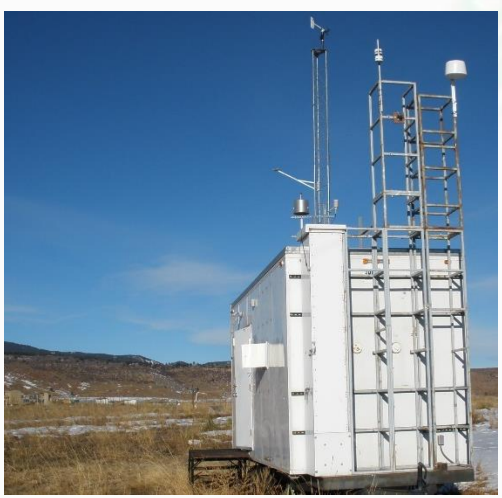


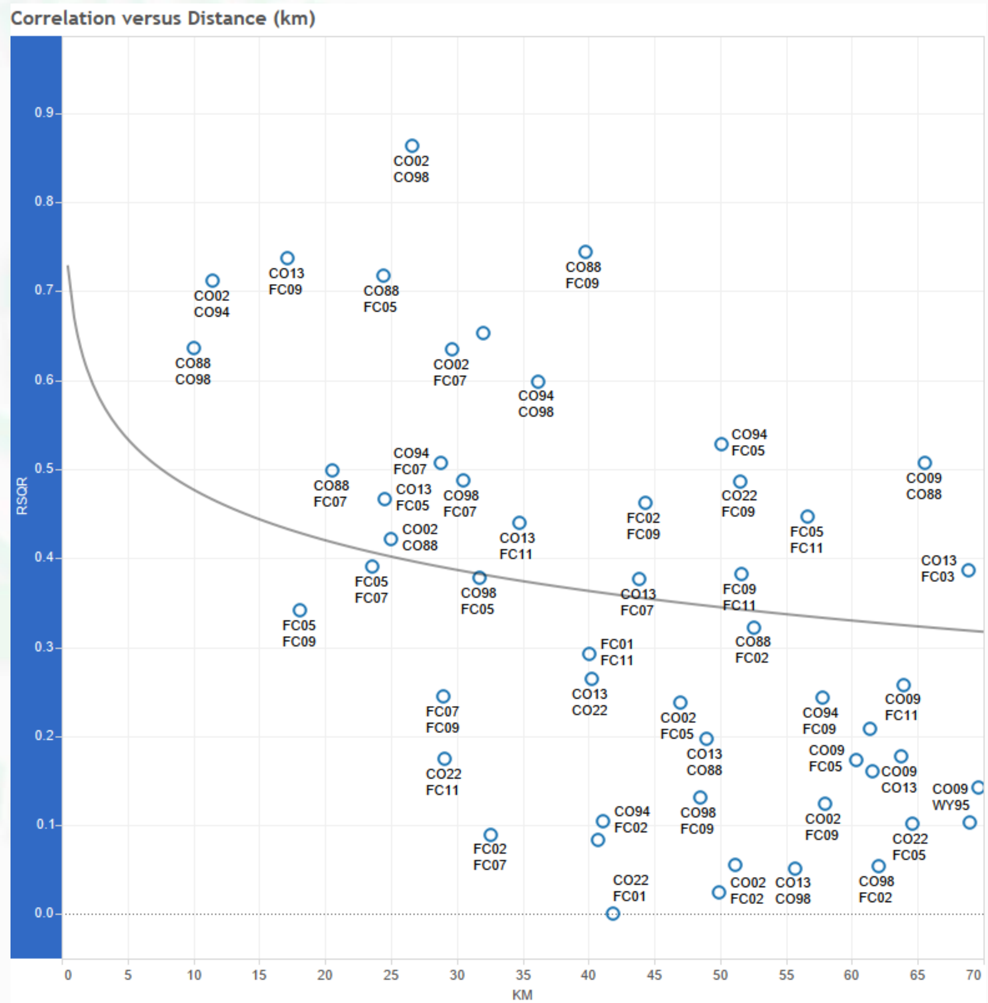


NH_3 Spatial Variability Study

Fort Collins, CO – Animal operations







Conclusions from Spatial Variability Study

- Defining a radius of influence is going to be difficult for the AMoN sites
- Need additional information on the magnitude and direction of the fluxes
- Site specific bidirectional flux modeling will be informative, but challenging
  - 2 week measurements; not hourly
  - Modeling needs site specific information
    - Site characterization to explore the level of information needed to drive the model

Site Characterization Study

- Develop a methodology for using 2-week average AMoN concentrations in a bi-directional NH_3 flux model
- Provide NADP with a model for calculating and reporting net and component NH_3 fluxes at AMoN sites
- Inform the use of AMoN measurements and modeling in TDEP maps

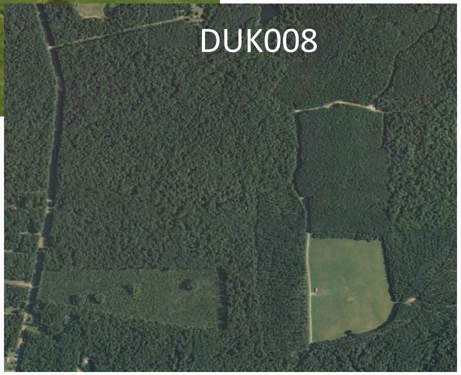
Study Design

- Develop biogeochemical datasets to improve parameterizations of NH_3 compensation points
- Assess model sensitivity to surface parameterizations
- Assess impact of measured versus modeled meteorological inputs
- Develop methodology for applying diurnal profile to 2-week AMoN concentration

Site Selection

- Three pilot sites were selected based on land use, vegetation type, soil type, and atmospheric NH_3 concentrations

- CASTNET, NADP/NTN, and NADP/AMoN sites
  - Chiricahua National Monument (CHA467, AZ)
    - Soil type – 58% thin soil/rock, 18% silt loam, 11% gravelly loam
    - Vegetation types – 60% sagebrush/grass, 26% oak, 8% juniper
    - AMoN ‘15 = 0.9 ug/m^3 (0 – 2.3 ug/m^3)
  - Bondville (BVL130, IL)
    - Soil type – 62% silty clay loam, 38% silt loam
    - Vegetation type – 92% Easter cool temperature row crop
    - AMoN ‘15 = 1.4 ug/m^3 (0.3 – 3.3 ug/m^3)
  - Duke Forest (DUK008, NC)
    - Soil type – 48% gravelly loam, 33% loam
    - Vegetation type – 76% mixed hardwood, 17% pine, 7% grass
    - AMoN ‘15 = 0.6 ug/m^3 (0.2 – 1.1 ug/m^3)



Field Measurements

Category	Analysis	Data	Comments
Meteorological measurements	3D wind components, Solar radiation, temperature (2 and 9m), wetness, wind speed and direction	Hourly average	Recorded by data logger
Soil Properties	Moisture, temperature	Hourly average	Recorded by data logger
Soil Chemistry	Moisture, $[NH_4^+]$, $[NO_3^-]$, pH	Seasonally (4x's)	15 locations per site; 5 soil cores within 1x1 m plot, separated by O and A horizons
Vegetation Properties	LAI	Summer, winter	15 locations
Vegetation Chemistry	Bulk leaf and litter: moisture, total [N], $[NH_4^+]$, pH	Seasonally (4x's)	15 locations per site; 50 g leaf litter collected (upper & lower canopy); green leaves from 3-5 trees

Summary

- Using the TDEP approach to determine total deposition of NH_3 presents some challenges
- A simple radius of influence approach won't work – strong site-to-site differences
- Improving our knowledge of the sensitivity of the field scale modeling to the site specific parameters is important and will be informed by the site characterization study. This will also improve CMAQ modeling efforts.
- Developing an approach for modeling NH_3 flux at AMoN sites is not straightforward but it will serve many purposes