Issue Paper prepared for the 2017 Western States Air Quality Modeling Workshop
DRAFT August 31, 2017

Improved Estimates of Ammonia Emissions and Nitrogen Deposition

Background

Ammonia (NH_3) is a precursor to fine particulate ammonium nitrate and ammonium sulfates and thus contributes both to exceedances of the PM2.5 NAAQS and to regional haze. Dry deposition of NH_3 and wet deposition of ammonium (NH_4^+) are also important contributors to total nitrogen (N) deposition which contributes to acidification and eutrophication of sensitive lands and surface waters. While EPA does not regulate NH_3 as a criteria pollutant, states are required to evaluate NH_3 as a precursor to PM2.5, and research on the sources and fate of NH_3 is a high priority for federal land managers because of its contributions to N deposition and to regional haze in Class I areas and sensitive Class II areas. Major sources of NH_3 emissions include livestock operations and fertilizer use for agriculture with smaller contributions from fire, mobile sources and other biological and industrial sources.

Problem Statement

There is large uncertainty in estimates of ammonia emissions, both in source activity data, emission factors for sources, and process level emission models. Uncertainties in emissions vary across animal and fertilizer categories and uncertainty in cumulative agricultural emissions varies regionally with respect to interactions between emissions and climate. Deposition assessments employing landscape to regional scale models indicate that NH_3 dry deposition is an important contributor to inorganic N deposition. In the vicinity of sources, NH_3 may deposit rapidly to surfaces, resulting in strong spatial gradients in ambient NH_3 concentrations. However, owing to the complexity of modeling the "bidirectionality" of NH_3 air-surface exchange, NH_3 dry deposition remains a highly uncertain component of N deposition budgets. NHx that deposits to surfaces can re-volatilize and this makes it challenging to model the sources and fate of NHx. For example, a National Park Service funded study by Dr. Jeff Collett's research group at Colorado State University has observed high transient NH_3 concentrations in the morning near the surface that might be a result of re-volatilization of NH_3 deposited on dew covered surfaces at night. This and other recent work indicates that NH_3 observations as 24-hour or multi-day averages might not be sufficient to characterize the complex processes that affect NHx budgets and that improvements in the parameterizations underpinning current bidirectional air surface exchange models are urgently needed. In the atmosphere, gaseous NH_3 exists in thermodynamic equilibrium with aerosol ammonium, and therefore measurements of total ammonia ($NHx=NH_3+NH_4^+$) are needed to accurately characterize ammonia budgets. Improvements in regional model treatment of NH_3 emissions and deposition are needed to more accurately predict the formation and dynamics of inorganic aerosol and therefore better understand the sensitivity of PM2.5 to NH_3.

Research Topics

- More work is needed on the development of emission models and emissions inventories for NH_3.
    - Incorporation of EPIC modeling into the National Emissions Inventory
    - Collaboration with USDA on emissions from animal sources
    - Development and evaluation of best management practices for reducing NH3 emissions
- More work is needed to improve NHx deposition models.
    - Bidirectional flux parameterizations
    - Near-source deposition
- There is a need for more measurements of the diurnal profile and vertical profile of NHx, as well as flux measurements, to understand the roles of deposition and re-volatilization of NHx.
- Monitoring and modeling studies investigating NHx are needed in urban areas that violate the PM2.5 NAAQS and in Class I areas.
- Develop improved source apportionment tools for NHx.
- Improve understanding of influence of meteorological events on NHx deposition and aerosol processes.

Desired Outcomes

- Develop improved estimates of NH_3 emissions.
- Develop improved measurements and models of NHx deposition.
- Determine if PM2.5 formation in urban and remote areas is ammonia limited.
- Develop improved estimates of NHx deposition in Class I and sensitive Class II areas.
- Develop list of best management practices for mitigating NH_3 missions.