USDA Research Programs Related to Atmospheric Reactive N

Ray Knighton

Cooperative State Research, Education and Extension Service (CSREES)
Atmospheric N – N₂

Reactive Nitrogen

Soil Inorganic N (fertilizer)

Soil Organic N

Groundwater/wetlands/rain

Biological N Fixation

Animals

Nitrous Oxide

Ammonia

Intervention

- ↑ Efficiency
- Waste treatment
- BMPs
- ↑ Denitrification

July 29, 2009
In 2003, the agricultural sector was responsible for emissions of 433.3 Tg CO₂ Eq., or 6.3 percent of total U.S. greenhouse gas emissions.
Emissions

2001 Total U.S. Emissions of Ammonia
(4,998,000 short tons)

EPA Air Pollutant Emission Trends
(http://www.epa.gov/ttn/chief/trends/index.html)

July 29, 2009
Ammonium Trend, 1985-2004

The National Trend
+ 30% (median change)

NADP/NTN Ammonium Trend 1985-2004

INCREASING Trend

DECREASING Trend

<table>
<thead>
<tr>
<th>Number of Sites</th>
<th>Number Significant</th>
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<tr>
<td>143</td>
<td>93</td>
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<td>16</td>
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The National Trend
+ 30%
(median change)
CSREES Federal Assistance
Related to Atmospheric Reactive N

- Formula programs (Hatch & McIntire-Stennis)
  - $1M/yr
- Competitive grants (National Research Initiative)
  - $3.5M/yr
- Targeted programs (earmarks)
  - $2 M/yr
- Agreements with other Federal agencies (NADP)
  - $1.6M/yr cooperative agreement with Univ. of Illinois
CSREES Competitive Grants

- Emissions measurement and monitoring of NH$_3$ and N$_2$O
- Fate and transport
  - Modeling
  - Biogeochemistry
  - Atmospheric chemistry
- Mitigation practices
  - Control technologies
  - Policy, economic, and cultural barriers
Measuring NH3 emissions from hog barns

July 29, 2009
New dispersion models to describe buoyant plume rise from animal buildings.
ARS Air Quality Research Program

• Ammonia and Ammonium Emissions
  – The central regulatory issue is agriculturally-emitted ammonia as a major source of secondary, PM-2.5 particulates as a result of its interactions with other atmospheric compounds.
  – The focus of this research component is on
    • understanding ammonia emissions and their role in forming secondary particulates
    • developing methods to measure emissions
    • establishing emission factors for various agricultural activities
    • and suppressing ammonia and ammonium emissions beyond farm boundaries.
Manure & Byproduct Utilization Research Program

• Atmospheric Emissions
  – Three types of emissions (gases, particulates, and aerosols) affect air quality changes around animal operations, manure storage areas, and manure field application sites. Gases of particular interest include ammonia, odorous compounds, and greenhouse gases such as methane, carbon dioxide, and nitrous oxides. Ammonia emissions appear to have the greatest potential for adverse environmental and health impacts, while generation and transport of malodorous compounds provoke the greatest public concern.

• Control Technologies
  – To develop cost-effective methods of emissions reduction and control improved methods to measure and quantify emissions will be required.

• Measurement and Modeling
  – A greater understanding also will be needed of the mechanisms responsible for emissions, emission rates resulting from a variety of animal management practices, and methods to predict dispersion and transport of emissions across the landscape.
Effect of Crude Protein in Cattle Diets on NH₃ Emission

Trial 1, June-July, 2002

Cumulative NH₃-N Loss (g)

Days After Manure Applied

- 13% CP Diet
- 11.5% CP Diet

July 29, 2009
Tillage Effects on NH₃ Loss Dairy Slurry (Wind Tunnel, 7d)

Note: Management factors can be compared with replication
Forest Service Research

• Atmospheric deposition effects in the western U.S.
  – Critical loads
    • Chronic high N deposition to the normally N-limited systems of California is a major ecological perturbation with unknown long term effects
  – Passive ammonia monitoring
    • Monitoring of air pollution concentrations, deposition, and effects is needed to determine the extent and magnitude of pollutant deposition in areas at risk and determine forest stand structure and composition response.
The potential acidity and excess nitrogen content of the atmospheric deposition in the CRG has raised concerns that protected cultural resources, particularly Indian rock art, are being harmed and over time will deteriorate from winter immersion in this polluted air mass.

The Columbia River Gorge (CRG) has become a conduit of air pollution transport from emissions sources located within and to the west and east of the gorge.
Measurement - Gaps

• New, fast response, and highly sensitive techniques for the measurement of ammonia/ammonium and nitrous oxide from plant and soil surfaces.
• Comparability of data from techniques being employed to measure ammonia/ammonium and nitrous oxide.
• Procedures to mitigate the impact of biological processes on the measurement of ammonium in precipitation.
• Better methods for evaluating field fluxes of nitrous oxide from fertilizers and land-applied agricultural wastes.
Models - Gaps

- Numerical methods that accurately characterize the formation of ammonium-containing aerosols, including their size distribution and optical properties.
- Model representations to account for the complex atmosphere/surface exchange processes involving ammonia and nitrous oxide.
- Buoyant plume rise schemes appropriate to the dispersion of ammonia and aerosols from animal-rearing facilities.
Mechanisms for Filling the Gaps

• Intramural and extramural federal research
  – USDA/ARS air quality research
  – USDA/Forest Service emissions from fire
  – USDA/CSREES Agriculture and Food Research Initiative
    $5 M/yr ~ 70% related to NH$_3$ and N$_2$O
    • Measurement and Monitoring
    • Fate and Transport (Modeling)
    • Mitigation
  – EPA
  – NOAA
  – USGS
  – NPS
  – Opportunities for joint extramural federal research?
Mechanisms for Filling the Gaps

- State sponsored research
  - CA, TX, and IA
- Federal monitoring
  - NTN
  - CASTNet
  - AIRMoN
  - National Air Emissions Monitoring Study
  - LTM/TIME
The National Air Emission Monitoring Study (NAEMS)

• Established in 2006 by a voluntary Air Compliance Agreement between the EPA and the pork, dairy, egg and broiler industries
• Will address the lack of scientific data.
• Livestock producers have provided the financial support for the NAEMS so that emissions data can be collected at select sites to:
  – 1) accurately assess emissions from livestock operations and compile a database for estimation of emission rates, and
  – 2) promote a national consensus for emissions-estimation methods/procedures from livestock operations.
Locations of NAEMS sites (Barns and Open-Source).

Legend:
1 – Broilers
2 – Layers
3 – Finishers (Swine)
4 – Sows (Swine)
5 – Dairies
A – Area or open Source
B – Barn source
• Funding for the NAEMS has been provided by the National Pork Board, the National Chicken Council, the National Milk Producers Federation, and the American Egg Board, via a not-for-profit organization called the Agricultural Air Research Council. The NAEMS is overseen by the EPA Office of Air Quality Planning and Standards (OAQPS) and led by Purdue University. Other universities involved in the study are: Cornell University, Iowa State University, North Carolina State University, Texas A & M University, the University of California - Davis, the University of Minnesota, and Washington State University.
Mechanisms for Filling the Gaps

• Field Campaigns
  – Texas Air Quality Study (TexAQS) - Gulf of Mexico Atmospheric Composition and Climate Study (GoMACCS)

• Symposia and Workshops
  – Agricultural Air Quality Workshop-June, 2006
    • 300 papers (several peer-reviewed Journal special issues)
  – Western Dairy Symposium – March, 2006
  – Professional Societies (ASABE, ASA)
Mechanisms for Filling the Gaps

• Research and Monitoring Coordination
  – CENR Air Quality Research Subcommittee
  – USDA Agricultural Air Quality Taskforce
  – USDA/EPA Research Coordination Committee
  – Air Quality Assessment and Forecasting Taskforce
  – National Atmospheric Deposition Program
Environmental Issues

• Hypoxia/Eutrophication
  – Nitrogen wet and dry deposition to surface waters

• Critical Loads
  – Deposition to sensitive ecosystems
    • Rocky Mountain National Park
Environmental Issues

- **Greenhouse gases**
  - Nitrous oxides
  - Methane (anaerobic digestion/NOx)

- **Particulate Matter**
  - Ammonia to fine particulates
  - Dust from production

- **Odor**
  - VOCs
  - Hydrogen sulfide (hazardous)
  - Ammonia (hazardous-CERCLA, EPCRA)
Research Needs & Data Gaps for N Emissions from Agriculture

• What have we learned over the last 5 years
  – Better understanding of gas and particulate matter concentrations in animal production systems
  – Better understanding of the fate and transport of gas and particulates
  – Better characterization of the diurnal and seasonal nature of gas concentrations
  – Better monitoring and measurement systems
  – Better understanding of particle size distributions and chemistry of particulates
  – Better estimates of errors associated with particulate matter measurements and methods
Research Needs & Data Gaps for N Emissions from Agriculture

• Are we there yet?
• What are the goals?
  – To predict an emission rate at any point in the production cycle for the whole farm.
  – To predict the fate and transport of emissions downwind.
  – To measure dry and wet deposition.
  – To validate regional and local transport models.
  – To mitigate emissions.
2009 USDA AFRI Air Quality Program Emphasis Areas

• Emission data from production practices – particulates, gases/odors

• Improved measurement protocols/instrumentation for within field and edge of field boundaries

• Practices for mitigating emissions

• Fate and transport of emitted particulates and gases
Questions

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