Review of Ammonia Emission Modeling Techniques for Natural Landscapes and Fertilized Soils

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NH_3 Fluxes to/from Natural Landscapes

- Ammonia can be either emitted from or deposited to natural landscapes. The magnitude and direction of NH_3 flux depends on the NH_3 concentration in the air, the levels of ammonium in leaves and in the soil, other vegetative conditions, and meteorological and climactic conditions.

- Fluxes measured over short time spans (typically less than one day) range from -1300 to 700 ng m^{-2} s^{-1} (where negative values denote deposition).

- Longer-term fluxes are much lower than short term peaks but still vary over a wide range.

Survey of NH_3 flux measurements over forests

Study	Long-term fluxes (ng m^{-2} s^{-1})	Short-term fluxes (ng m^{-2} s^{-1})
Anderson et al. (2003)	0.03 to 0.05	
Pryor et al. (2001)	-0.23	Up to +55
Wyers and Erisman (1998)	0.16 to 0.44	-1000 to +700
Andersen et al. (1999)	-9.1	
Langford and Fehsenfeld (1992)	-10 to 1.2	
Bouwman et al. (1977)	0.03 to 3	
Schlesinger and Hartley (1992)	3.8 to 38	
Andersen et al. (1993)		-300 to +50
Duyzer et al. (1994)		-1300 to +300
Sutton et al. (1995)		-950 to +630
Kim et al. (1973)		+570

Recommended Bidirectional Flux Algorithm for Natural Landscapes

We recommend an algorithm developed by Sutton *et al.* (1995), which computes the flux (F) based on a resistance approach.

- F_{emis} could be calculated as part of an emissions model.

- F_{depos} could be calculated as part of the deposition algorithm within the atmospheric simulation model.

$$F = F_{emis} - F_{depos}$$

$$F_{emis} = \frac{C_c}{R_s + (R_a + R_b)(R_s/R_w + 1)}$$

$$F_{depos} = \frac{C_g(R_s + R_w)}{R_w R_s + (R_a + R_b)(R_s + R_w)}$$

where:
F_{emis} is the gross potential emission flux if the ambient NH_3 concentration was equal to zero;
F_{depos} is the the amount that the potential flux is reduced by the presence of ambient ammonia;
C_c is the canopy average compensation point (µg m^{-3});
C_s is the stomatal compensation point (µg m^{-3});
R_w is the cuticular resistance (s m^{-1}); and,
R_s is the stomatal resistance (s m^{-1}).

The stomatal compensation point concentration is determined by the apoplastic concentrations of NH_4^+ and H^+ in the leaf, the dissociation constant for NH_4^+ and the Henry's Law constant for NH_3. The cuticular resistance is a function of relative humidity, and is specific to the type of vegetation.

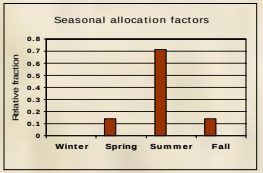
Background and Purpose

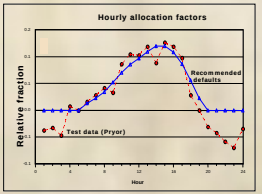
Air quality modeling of PM2.5 and regional haze is being hampered by uncertainties in the temporal and spatial patterns of ammonia (NH_3) emissions. NH_3 is an important precursor in the formation of secondary particulate matter (ammonium sulfate and ammonium nitrate).

The Emissions Inventory Improvement Program (EIIP) and EPA have funded this study to review short-term emissions from natural landscapes and fertilized soils. To promote public review and comment, preliminary recommendations are presented here.

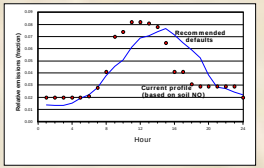
Recommended Default Emission and Temporal Allocation Factors for Natural Landscapes

Vegetation	Emission factors (ng m^{-2} s^{-1})	Estimated emissions in continental US (Gg/yr)
Forests	1.2	58
Grasslands	0.9	32
Shrublands	1.3	46
Deserts	0.3	<1
Total		137





Recommended Default Hourly Allocation Factors for Fertilized Soils



Seasonal Allocations of Fertilizer Emissions

Available data

- CMU Inventory
  - › Uses semiannual sales data at the county-level for 1995 available from the Association of American Plant Food Control Officials.
  - › Incorporates National Agricultural Statistics Service (NASS) crop calendars to estimate monthly fertilizer application rates for each county.
- CENRAP Inventory
  - › Updated the AAPFCO sales data to 2002 for the Central U.S.

Recommended method for seasonal allocation

- Short term -- Use county-level and monthly distributions of fertilizer application from the CMU inventory.
- Long term – Make periodic updates to the CMU crop calendar approach using the semiannual AAPFCO fertilizer sales data.

Review Comments

EIIP and EPA are seeking reviews and comments on this study. The full report may be downloaded at www.epa.gov/ttn/chief.

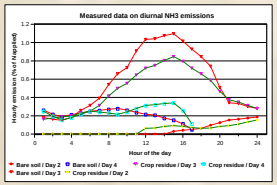
Short-term Variations of NH_3 Emissions from Fertilizer Application

- The NEI estimates NH_3 emissions from synthetic fertilizers at ~630 Gg/yr, or 21% of total emissions from all sources.
- Most emissions occur within a few weeks after fertilizer application.

Models for Short-term Variation from Fertilized Soils?

- Several emission models have been developed to evaluate the impacts of different fertilizer applications on evaporative losses of NH3.
- Present versions of these models are not adaptable to the calculation of emission rates or temporal emission variations.
- In general, these models require inputs for a wide array of parameters, including fertilizer application rate, time since application, soil type, soil pH, soil temperature, soil moisture content, air temperature, and wind speed.
- Many of these parameters, especially the time since application, are not routinely-available for geographical scales above an individual farm.
- The study examined these models and developed an approach for taking into account daily variations in NH3 emissions when the date of fertilizer application is known.

Measured Diurnal Variation over Fertilized Soils



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