Calculation method of N_2O flux measurements by static chambers

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Presented at the 3rd NitroEurope IP annual meeting, 18 - 21 February 2008, Gent, Belgium

ECN-L--08-065 February 2008

Energy research Centre of the Netherlands

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ECN

Literature review

VOL. 5, NO. 9 GEOPHYSICAL RESEARCH LETTERS SEPTEMBER 1978

A NUMERICAL EVALUATION OF CHAMBER METHODS FOR DETERMINING GAS FLUXES

Allan D. Matthias, Douglas N. Yarger, and Robert S. Weinbeck

Departments of Agronomy and Earth Sciences, Iowa State University, Ames, Iowa, 50011

Abstract. Mathematical simulations of ni
oxide (N_2O) flux from homogeneous soil into a
surface chambers have been done for both a c
type of chamber in which soil air is static
collected and an open type of chamber in whi
ambient air is dynamically drawn across the
surface. Results indicate that chamber-meas
fluxes over land surfaces may be subject to
siderable uncertainty, due in part to concen
tion gradient changes within the soil profil
that are a function of the type and the size
the chamber. Assessment of the uncertaintie
chamber flux determinations are reported. I
reasonable parameters closed-chamber flux va
may be underestimated by as much as 55%. Da
analysis procedures are described that can i
prove the flux estimates. Use of open cham
may yield better flux estimates than closed
bers because of less disturbance to the natu
gas concentration profile within the soil.
application to N_2O flux measurements over w
also is included.

Trace Gas Emission in Chambers: A Non-Steady-State Diffusion Model

Gerald P. Livingston,* Gordon L. Hutchinson, and Kevork Spartalian

ABSTRACT

Non-steady-state (NSS) chambers are widely used to measure trace gas emissions from the Earth's surface to the atmosphere. Unfortunately, traditional interpretations of time-dependent chamber concentrations often systematically underestimate predeployment exchange rates because they do not accurately represent the fundamental physics of diffusive soil gas transport that follows chamber deployment. To address this issue, we formally derived a time-dependent diffusion model applicable to NSS chamber observations and evaluated its performance using simulated chamber headspace CO_2 concentration data generated by an independent, three-dimensional, numerical diffusion model. Using nonlinear regression to estimate the model parameters, we compared the performance of the non-steady-state diffusive flux estimator (NDFE) to that of the linear, quadratic, and steady-state diffusion models that are widely cited in the literature, determined its sensitivity to violation of the primary assumptions on which it is based, and addressed some of the practicalities of its application. In sharp contrast to the other models, NDFE proved an accurate and robust estimator of trace gas emissions across a wide range of soil, chamber design, and deployment scenarios.

CHAMBER MEASUREMENT OF SOIL-ATMOSPHERE GAS EXCHANGE: LINEAR VS. DIFFUSION-BASED FLUX MODELS

W. H. Anthony, G. L. Hutchinson,* and G. P. Livingston

Abstract

We compared linear regression with a diffusion-based model for N_2O flux estimation using non-steady-state chamber gas concentrations from a long-term study of N cycling in a managed grass pasture on sandy soil in southern Texas. Of 2224 chamber deployments, 449 met criteria established for using the diffusion-based model, which yielded flux estimates that averaged 54% larger than linear regression (n = 3)
Although they
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Biogeosciences, 4, 1005–1025, 2007
www.biogeosciences.net/4/1005/2007/

Biogeosciences

CO_2 flux determination by closed-chamber methods can be seriously biased by inappropriate application of linear regression

L. Kutzbach[1], J. Schneider[1], T. Sachs[2], M. Giebels[3], H. Nykänen[4], N. J. Shurpali[4], P. J. Martikainen[4], J. Alm[5], and M. Wilmking[1]

Why do most of the people still use a linear regression?

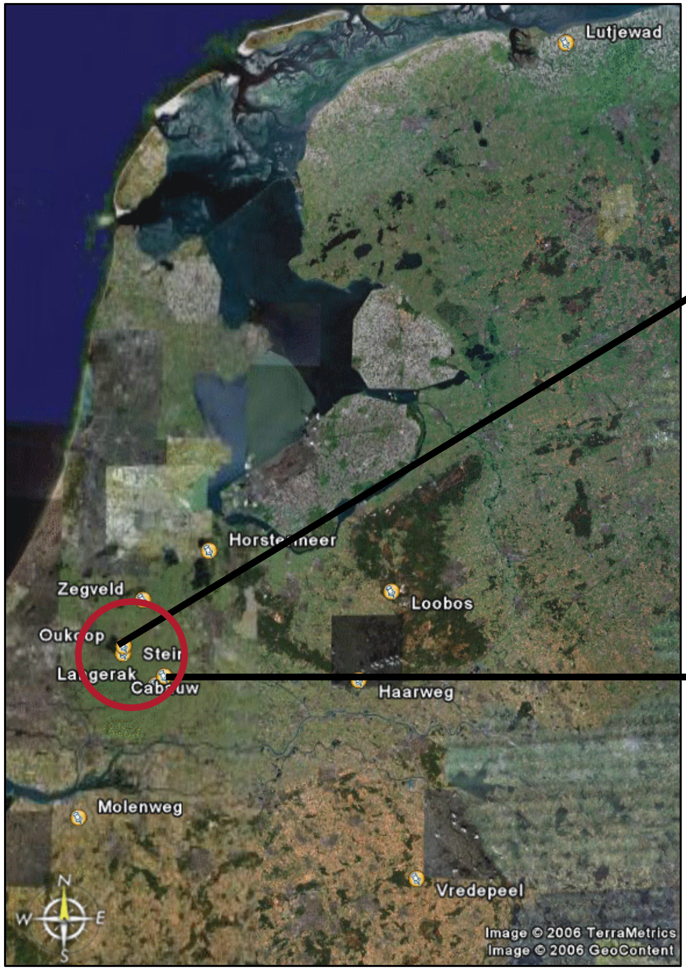
Possible reasons:

- Assumption that conentration behavior is linear over short measurement times.

- Assumption that non-linear concentration behavior can only be caused by leakage.

- Assumption that uncertainty due to spatial and temporal variation is much larger than the biases due to linear regression.

Measurement sites



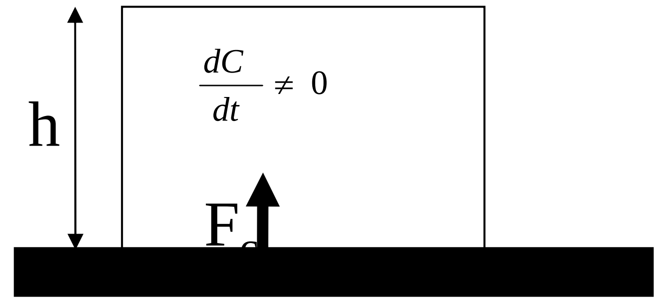
Oukoop

Cabauw

Measurement method (1)

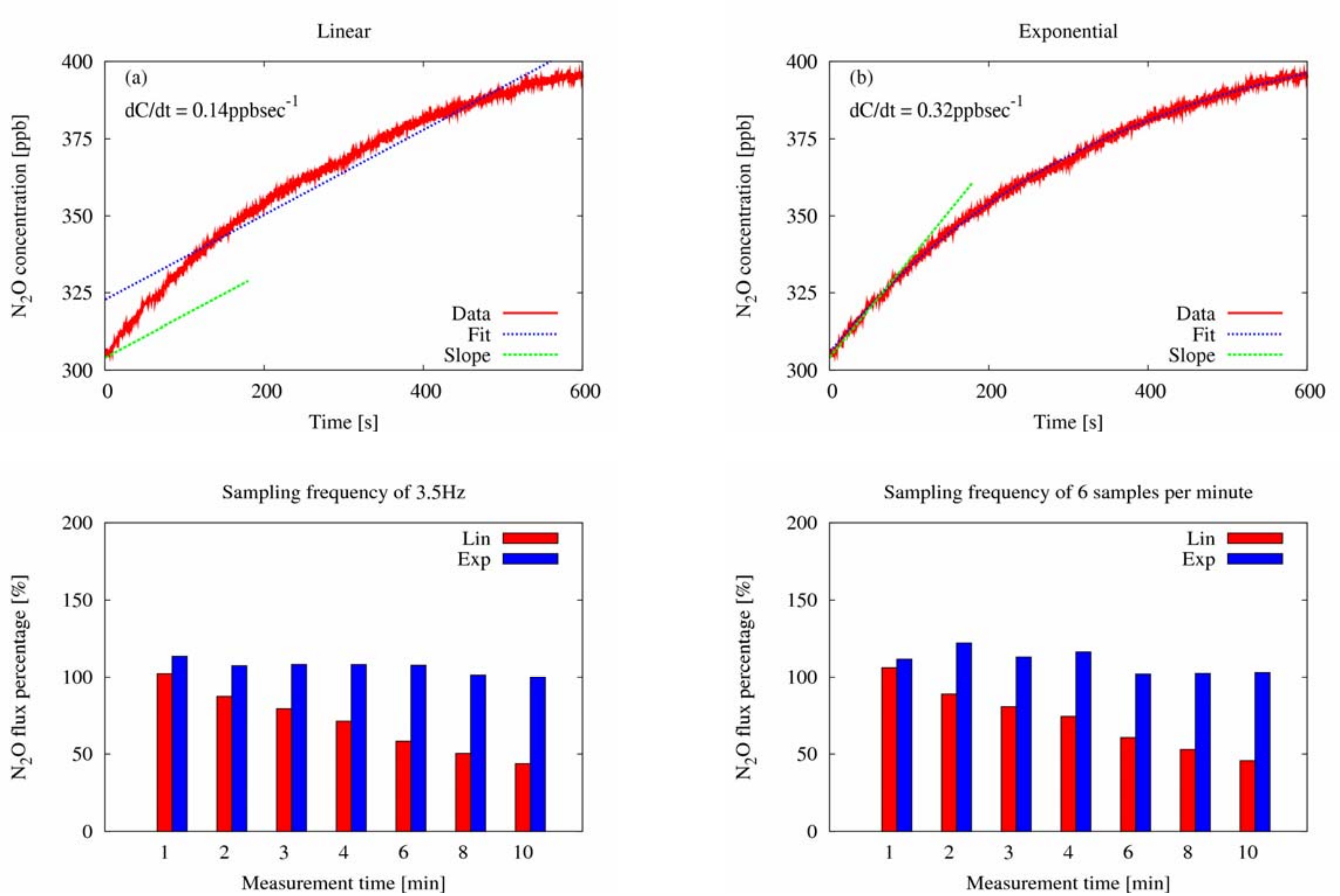
Oukoop

Fast chamber measurements



- N_2O concentrations measured with a QCL
- Sampling frequency of 3.5Hz

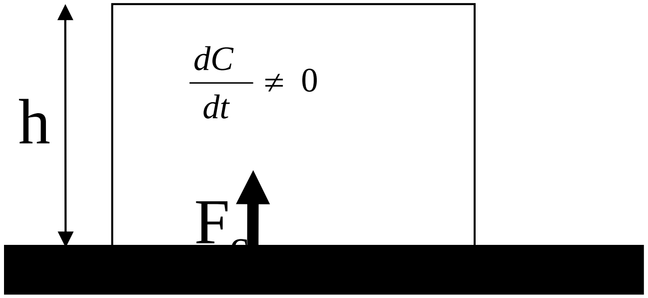
Assumption of short measurement times



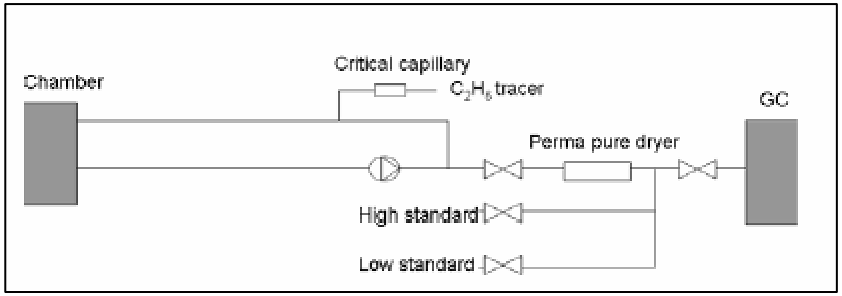
Measurement method (2)

Cabauw

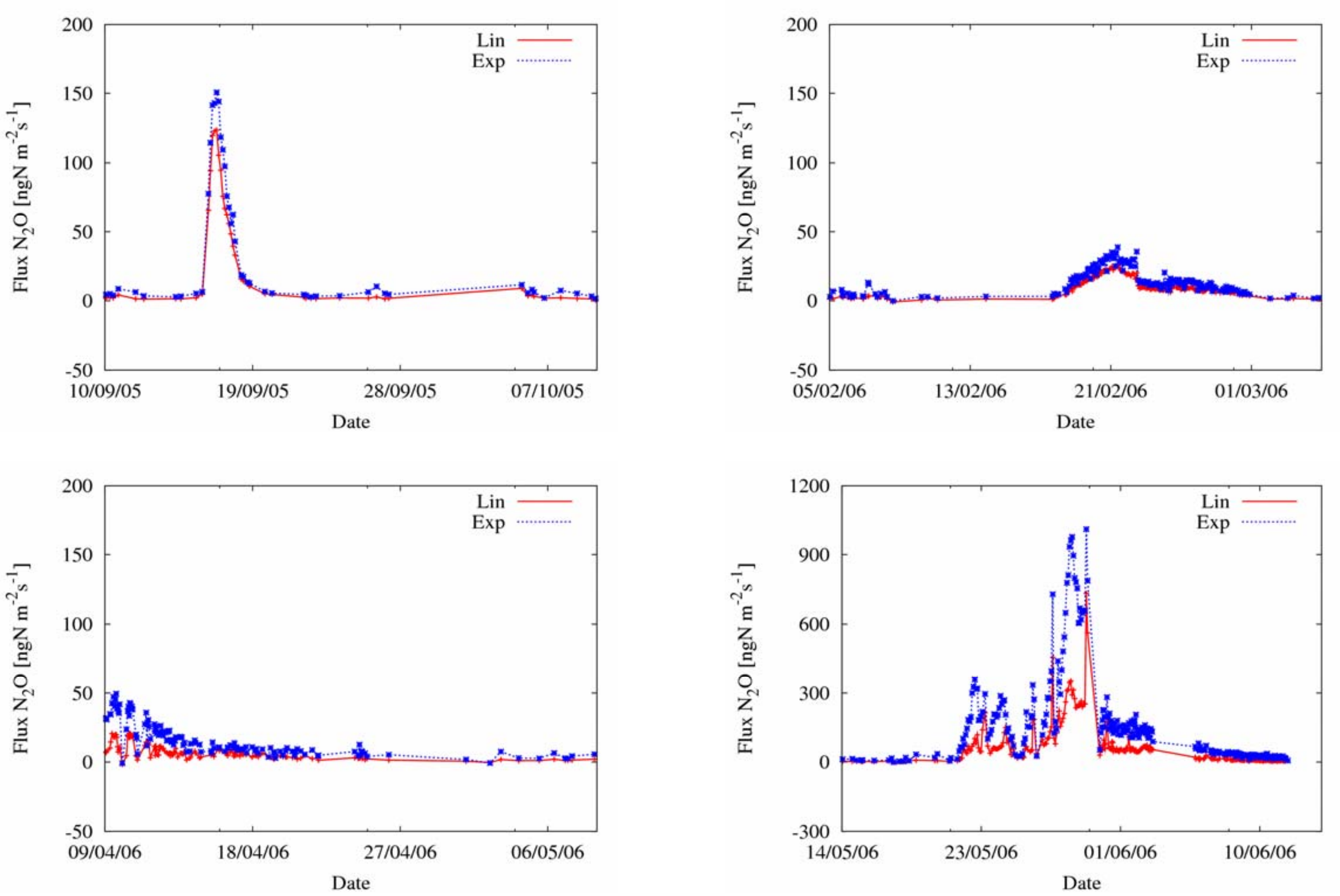
Automatic chamber measurements



Schematic representation



Comparison N_2O fluxes determined by two methods



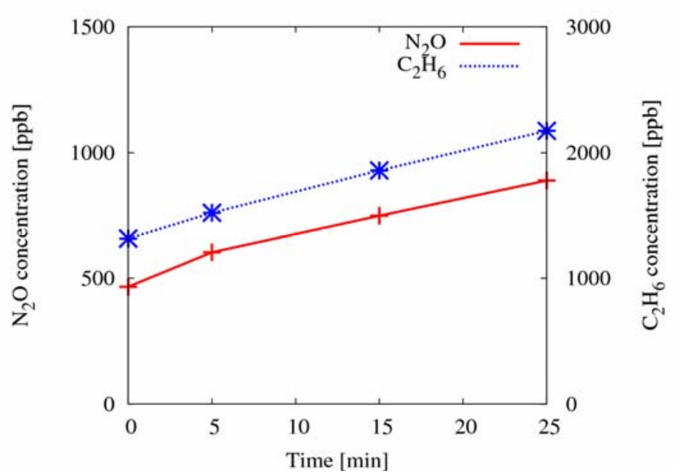
Comparison N_2O fluxes determined by two methods

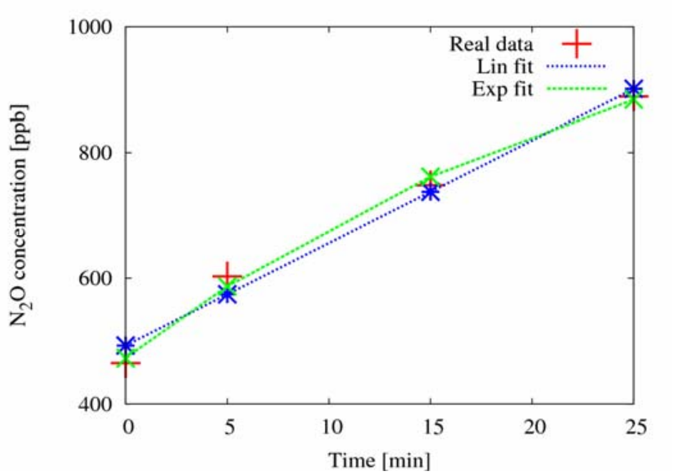
Table 4.1: *Summary of applied N and N_2O emissions of four fertilizing events at Cabauw in the Netherlands.*

Measurement period	Measurement method	Applied N [kgN ha^{-1}]	Cumulative emissions N_2O-N [kgN ha^{-1}]	Percentage emitted N_2O-N [%]	T [ºC]	R [mm]
10/09/05– 10/10/05	Linear	33	$22 \cdot 10^{-2}$	0.7	14	114
	Exponential		$32 \cdot 10^{-2}$	1.0		
05/02/06– 05/03/06	Linear	128	$12 \cdot 10^{-2}$	0.1	3	58
	Exponential		$19 \cdot 10^{-2}$	0.2		
09/04/06 - 09/05/06	Linear	60	$9 \cdot 10^{-2}$	0.1	11	15
	Exponential		$22 \cdot 10^{-2}$	0.4		
14/05/06-14/06/06	Linear	99	$146 \cdot 10^{-2}$	1.5	13	84
	Exponential		$331 \cdot 10^{-2}$	3.4		

Kroon et al., submitted

Non-linearity in case of a leak free chamber

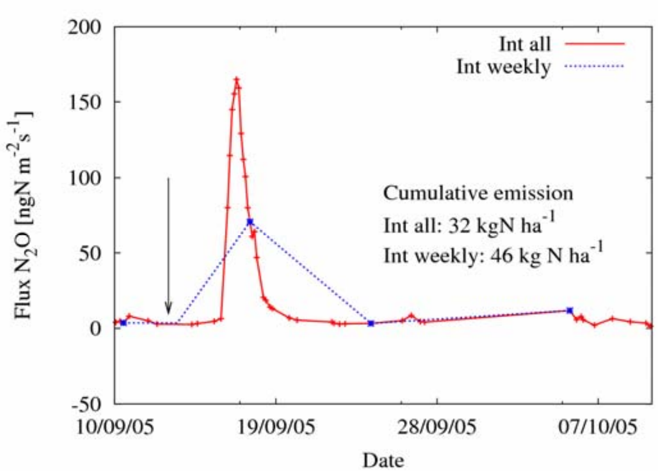


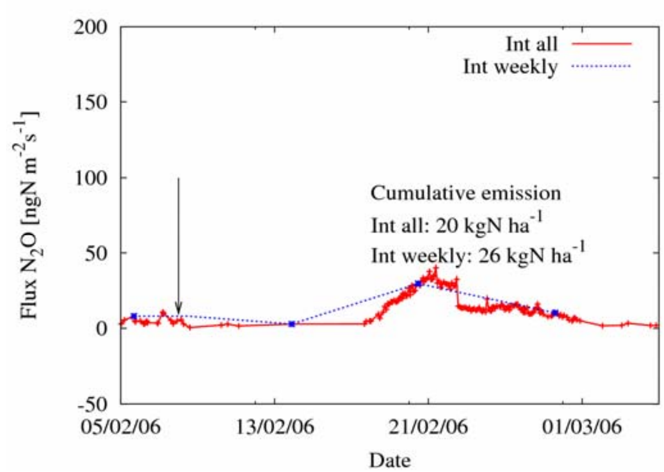


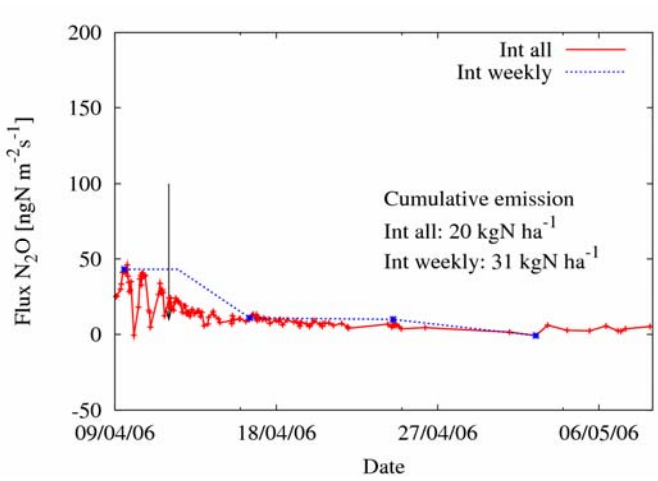
N_2O flux estimate:

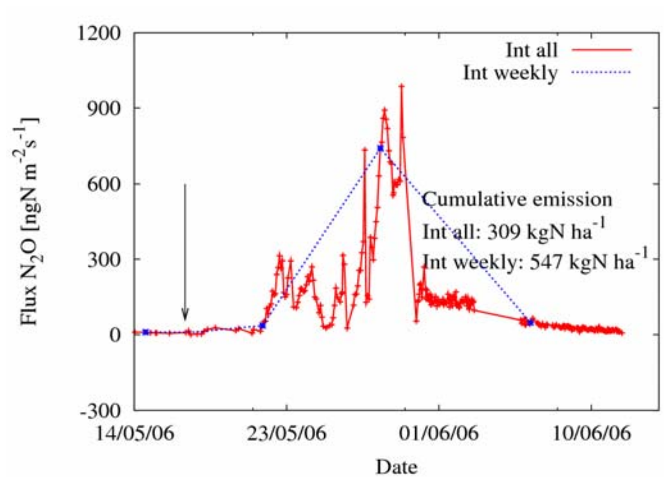
- Linear method -> 85 ngN $m^{-2}s^{-1}$
- Exponential method -> 150 ngN $m^{-2}s^{-1}$

Uncertainty due to temporal variation









Conclusion

Possible reasons:

- Assumption that concentration behavior is linear over short measurement times.

- Assumption that non-linear concentration behavior can only be caused by leakage.

- Assumption that uncertainty due to spatial and temporal variation is much larger than the biases due to linear regression.

Assumptions need to be proved

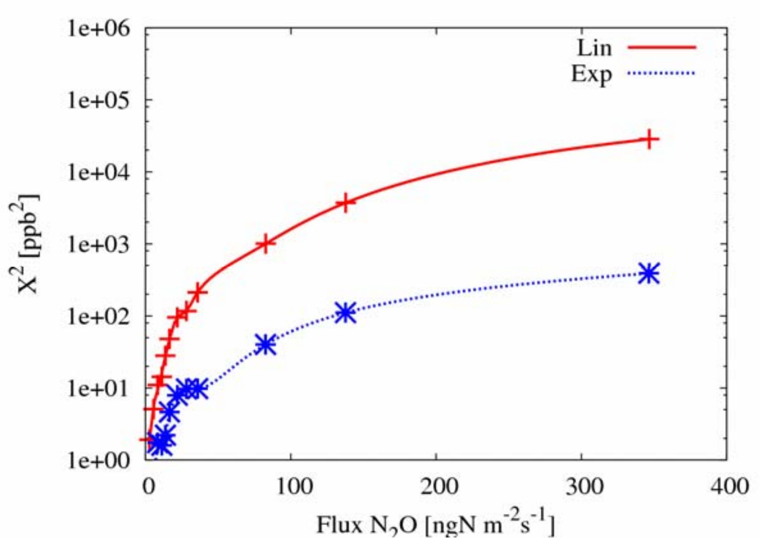
Advice

Test static chamber data for non-linearity by

- Comparing different methods and their goodness-of-fit
- Using an additional tracer like C_2H_6

Goodness-of-fit anaysis

$$\chi^2 = \sum_{i=1}^{N} \left(y_i - \hat{y}_i\right)^2$$



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