Yale 耶鲁大学-南京信息工程大学大气环境中心
Yale-NUIST Center on Atmospheric Environment

A discussion on the paper ''Reconciling the differences between top-down and bottom-up estimates of nitrous oxide emissions for the U.S. Corn Belt''

T.J. Griffis,X. Lee,J. M. Baker,et al.

GLOBAL BIOGEOCHEMICAL CYCLES, 2013

Zhang Yuanyuan
2014.10.31

Outline

- Introduction
- Methods
- Results and Discussion
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Introduction

- N_2O is a greenhouse gas with a large global warming potential and is a major cause of stratospheric ozone depletion. Croplands are the dominant source of N_2O.

- the EFs of global N budget (3.8% to 5.1%) much greater than IPCC recommends EFs (0.75% to 2%), both of those EFs have a large uncertainty.

- Here we use a tall tower N_2O measurements to evaluate the IPCC bottom-up and global 'top-down' EFs for the United States Corn Belt.

Methods

- Study Area

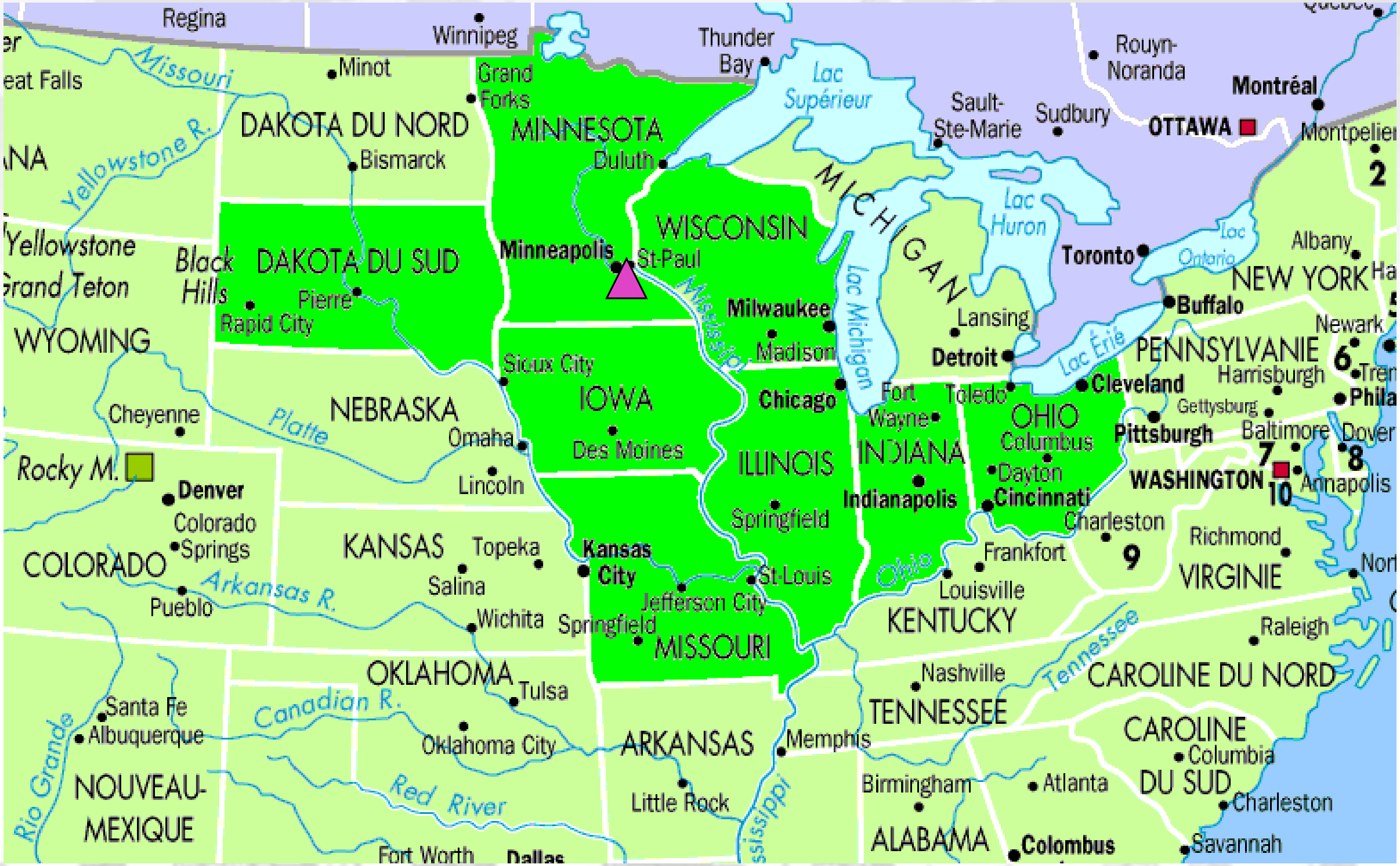

Table 1. Estimated synthetic nitrogen fertilizer, livestock populations, and manure-derived nitrogen for the Corn Belt

Crop	Area (10^6 ha)	Rate (kg N ha^{-1})	Total N (Tg N y^{-1})
Corn	24.6	142.6	3.5
Soybean	21.8	3.2	0.07
All wheat varieties	3.3	55.7	0.18
Cotton	0.12	77.2	0.009
Other	10.0	122.7	1.2
Total	**59.8**	-	**4.96**

Type	Population (10^6)	Rate (kg N $animal^{-1}$)	Total N (Tg N y^{-1})
Cattle	27.6	57.9	1.60
Swine	45.0	17.7	0.79
Sheep	1.2	6.6	0.008
Layers	146.5	0.43	0.06
Broilers	477.2	0.35	0.17
Turkey	46.5	1.6	0.07
Horses	0.85	39.7	0.03
Total	**744.9**	-	**2.74**

- Tall Tower N_2O Measurements
- Global N_2O Data Sets

Niwot Ridge, Colorado, USA, Mauna Loa, Hawaii, USA, Barrow, Alaska, USA, Summit Greenland, and the South Pole.

- Wavelet Analysis
- Chamber Measurements

➢Source Footprint Within the Corn Belt

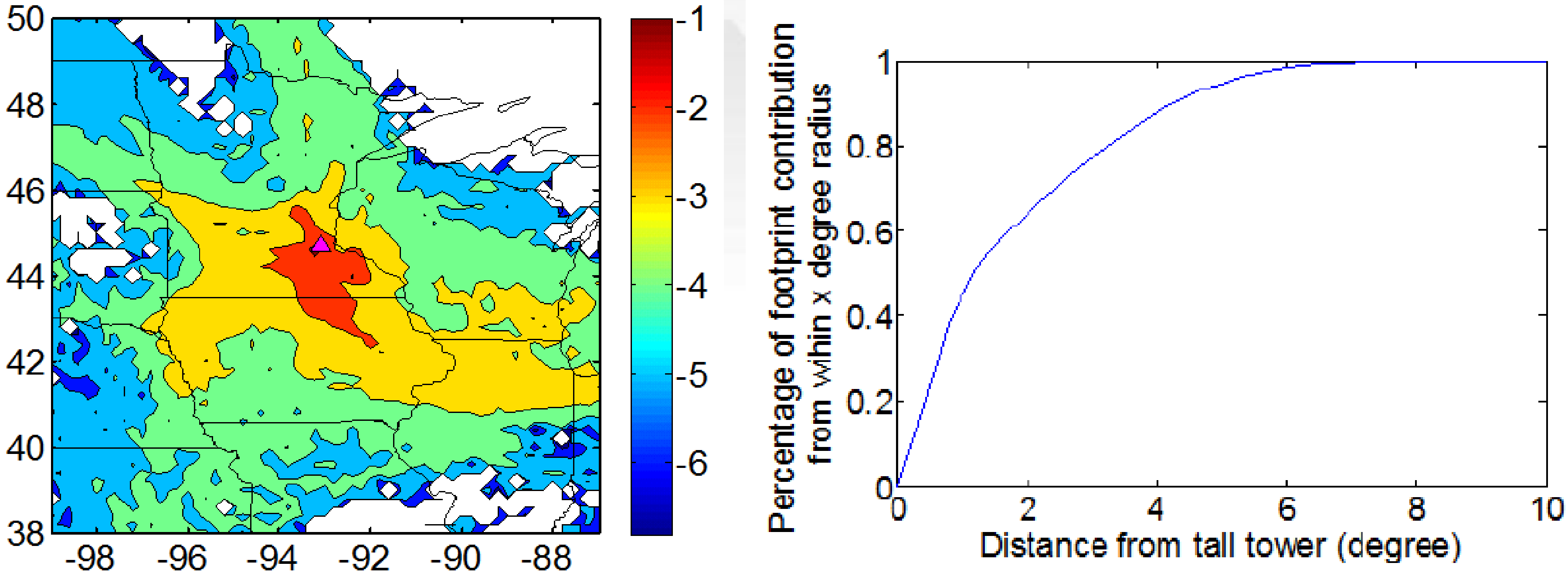

Figure 1. Concentration footprint of the tall tower determined using the STILT model in September 2009.

➢ Boundary Layer N_2O Budgets

1. nocturnal boundary layer (NBL):

$$F_{NBL} = \int_0^h \rho \frac{dc}{dt} dh \qquad (1)$$

ρ: the molar density of dry air, dc/dt: the change in N_2O mixing ratio during the night, h: the height of the nocturnal boundary layer.

$$h = 0.142 \frac{u_*}{f_c} \qquad (2)$$

u_*: friction velocity measured in the surface layer
f_c: Coriolis parameter

2、modified Bowen ratio (MBR):

$$F_{MBR} = Fc \frac{dc_1/dz}{dc_2/dz} = Fc \frac{dc_1}{dc_2} \qquad (3)$$

F_c: the eddy CO_2 flux

dc_1/dz and dc_2/dz: vertical gradients of N_2OandCO$_2$

3、equilibrium boundary layer (EBL):

$$F_{EBL} = \int_0^h \rho \frac{dc}{dt} dh + S(C_t - C_m) \qquad (4)$$

F_{EBL} : the surface flux

S : the subsidence of air from the free troposphere into the boundary layer (units of mol $m^{-2}s^{-1}$and positive toward the surface)

C_t andC_m: the mixing ratios of N_2O in the free atmosphere and mixed layer

Bottom-up N_2O Emission Estimates

N_2O Emission	pathways	EFs	uncertainty
direct	fertilizer (synthetic/organic)	0.01	0.003-0.03
	manure	0.02	0.007-0.06
indirect	volatization	0.01	0.002-0.05
	leaching/runoff	0.0075	0.0005-0.025

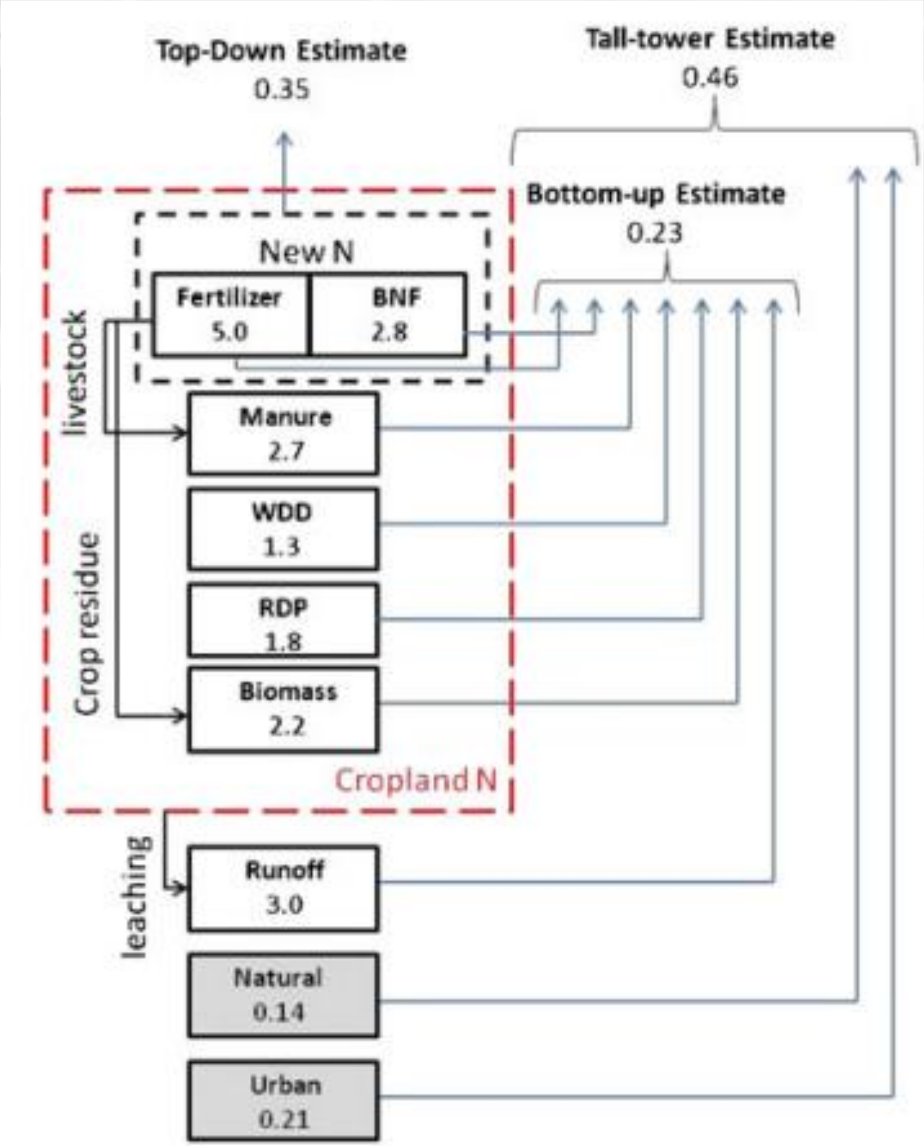

Figure 2. Nitrogen flows in the Corn Belt.

Results and Discussion

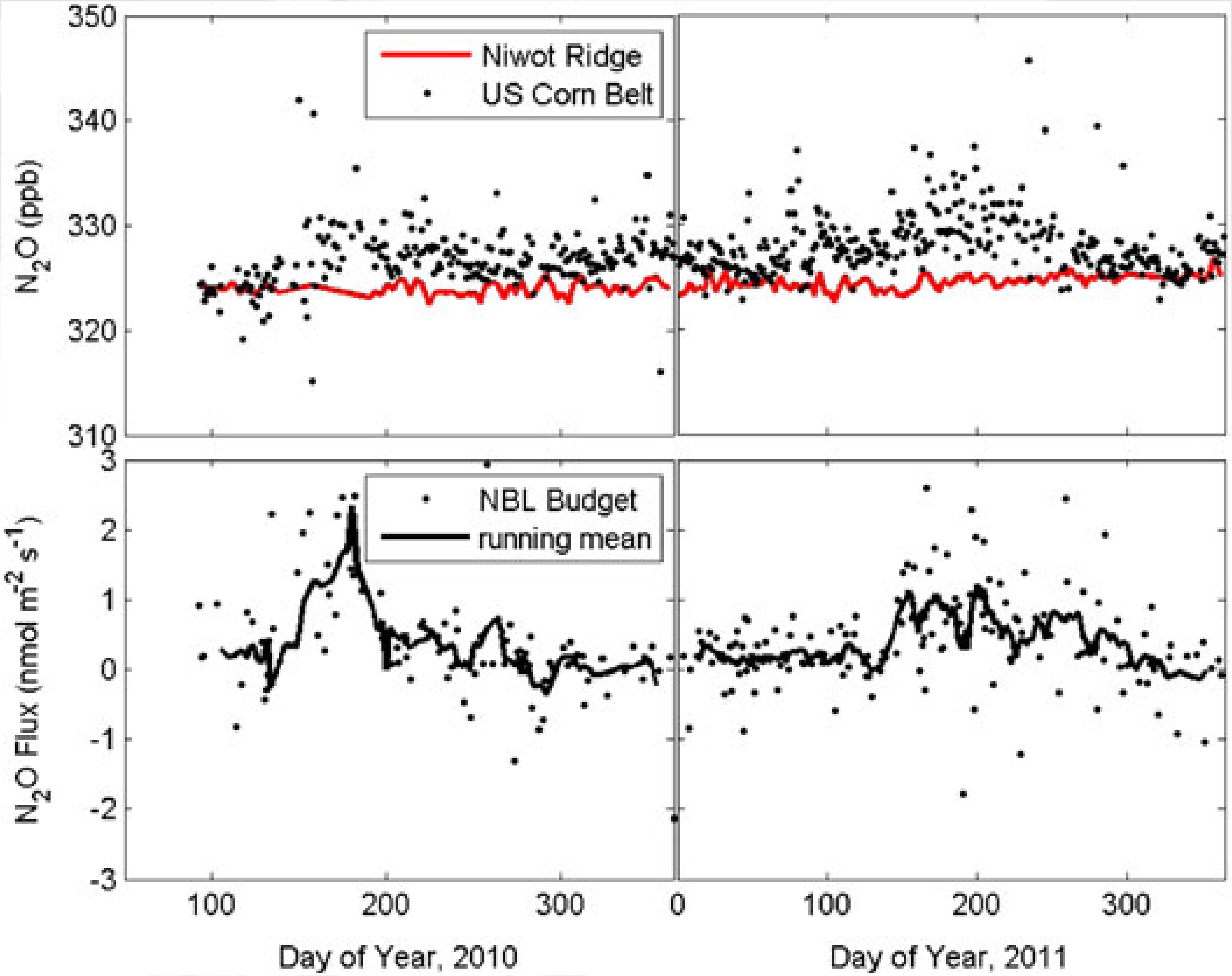

Figure 3. Tall tower atmospheric observations in the Corn Belt.

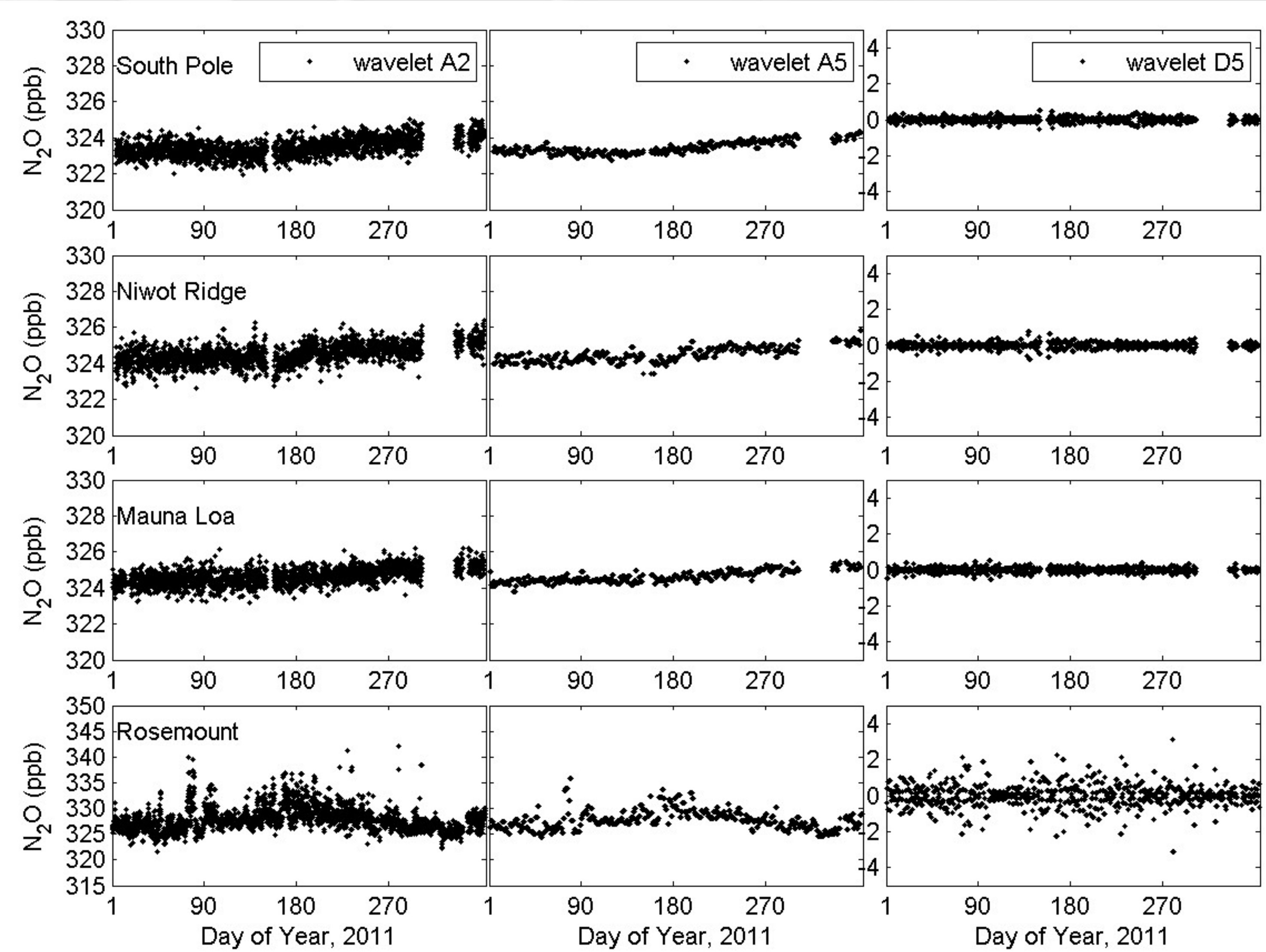

Figure 4. Wavelet analysis of N_2O concentration from select “background” sites and the Rosemount tall tower (100 m level).

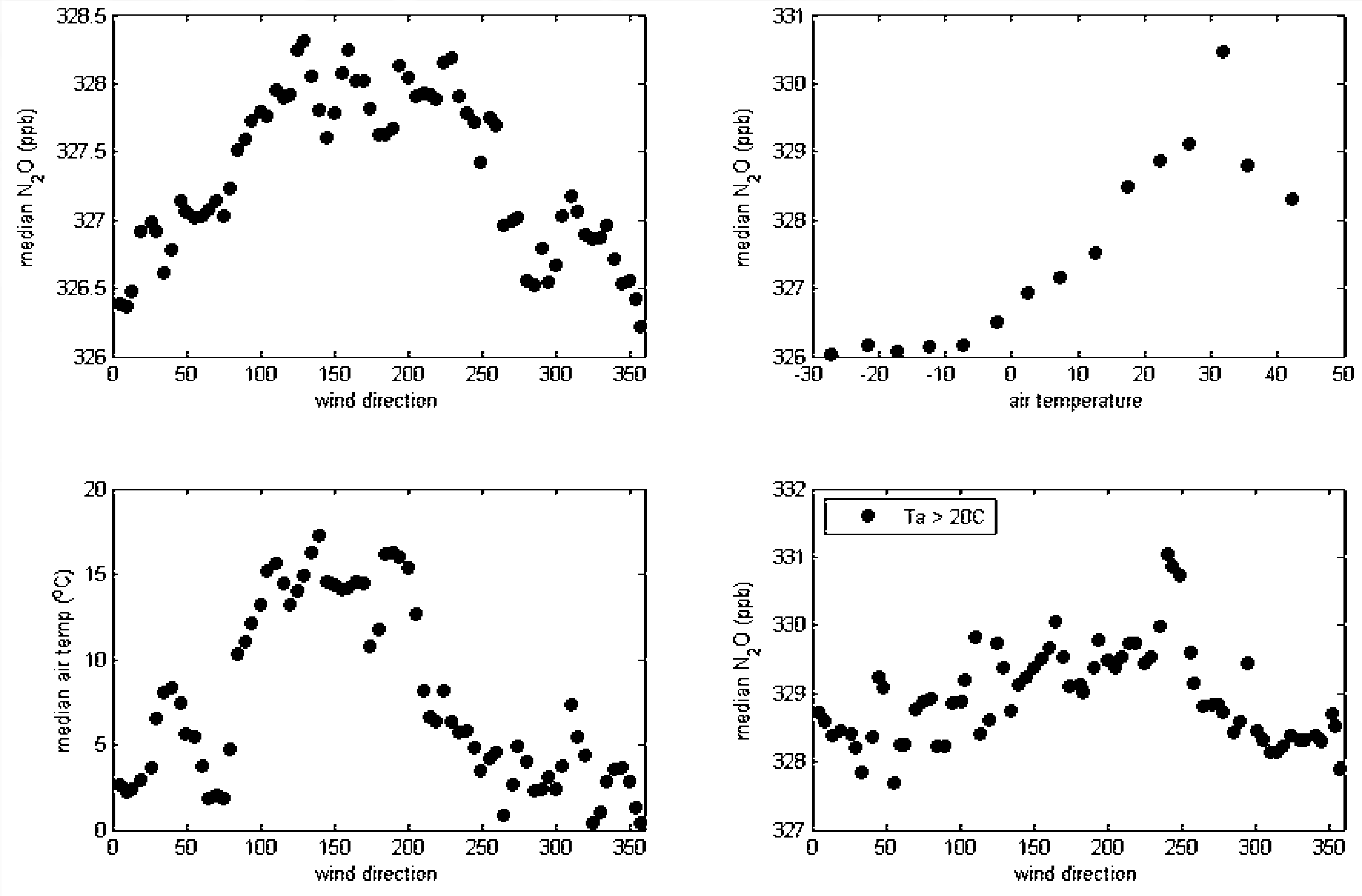

Figure 5. Influence of wind direction and air temperature on the tall tower N_2O observations measured at the 100 m level.

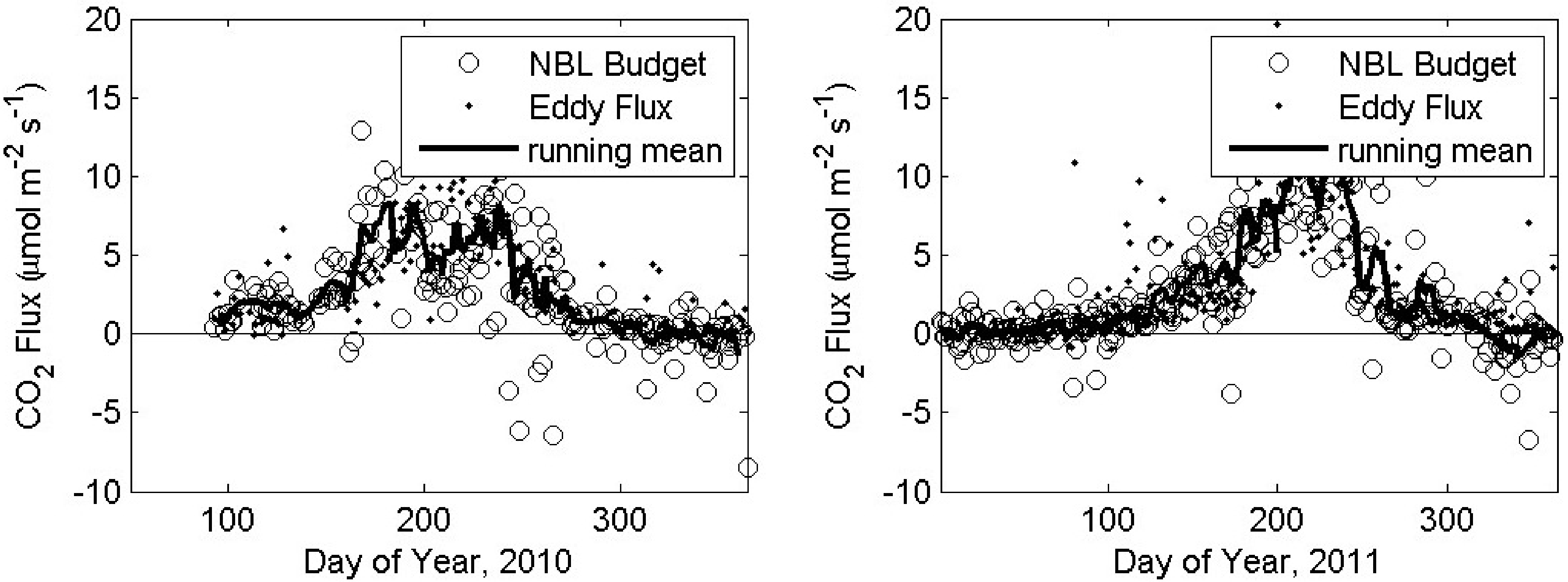

Figure 6. Comparison of the CO_2 nocturnal boundary layer budget and eddy covariance techniques.

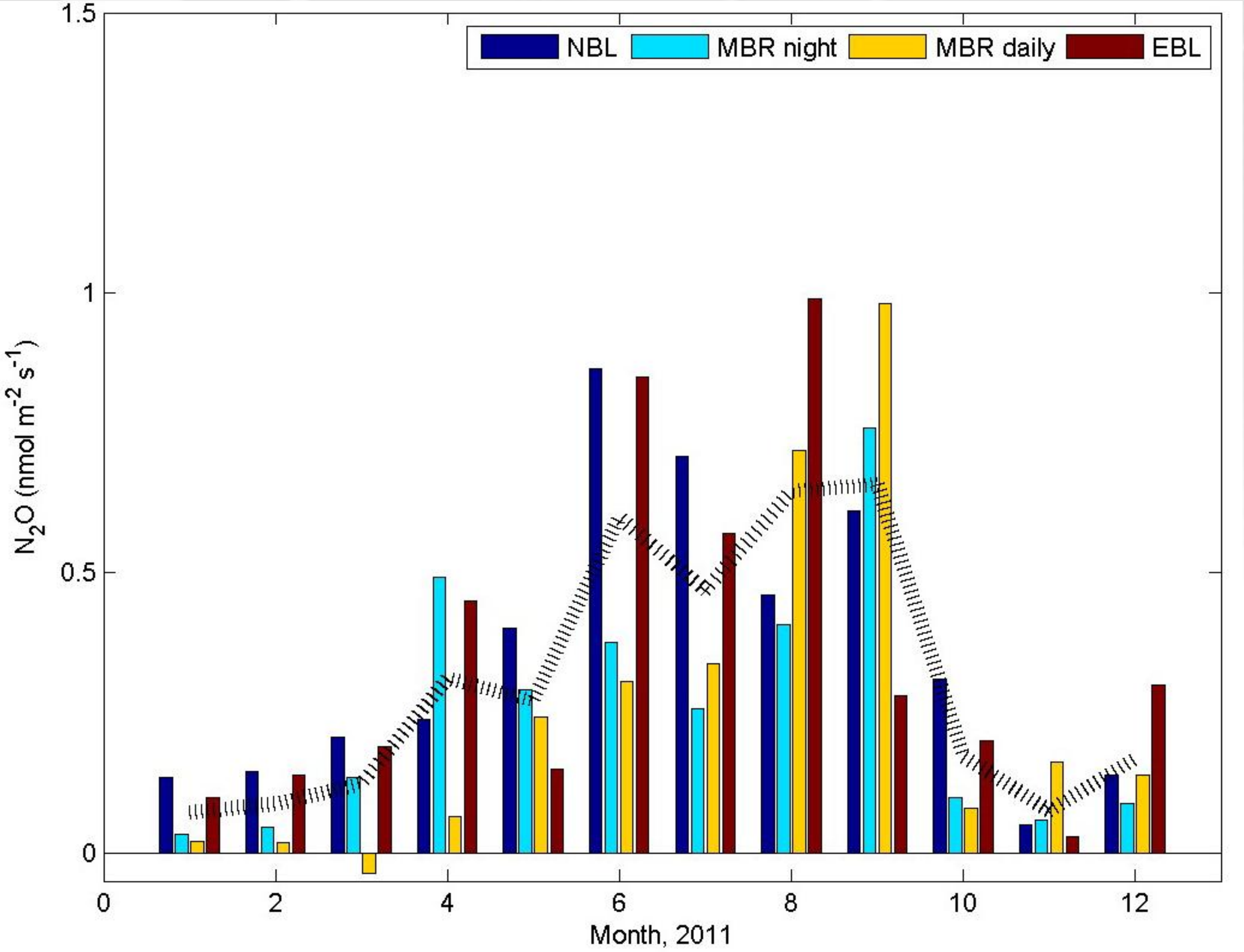

Figure 7. Mean monthly nitrous oxide flux estimates based on the NBL, MBR (night and daily), EBL techniques for 2011.

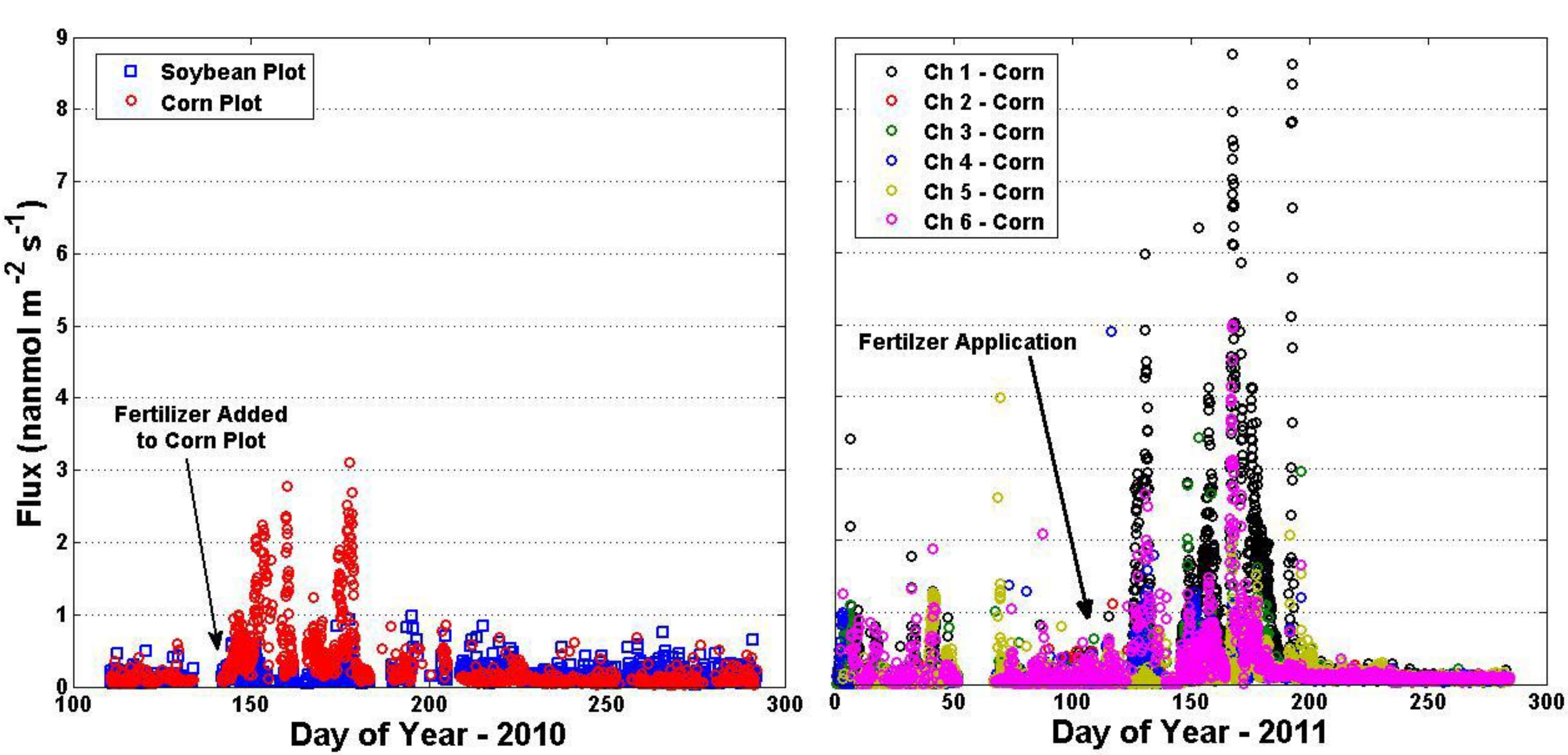

Figure 8. Hourly soil N_2O fluxes measured using an automated chamber system coupled to a tunable diode laser.

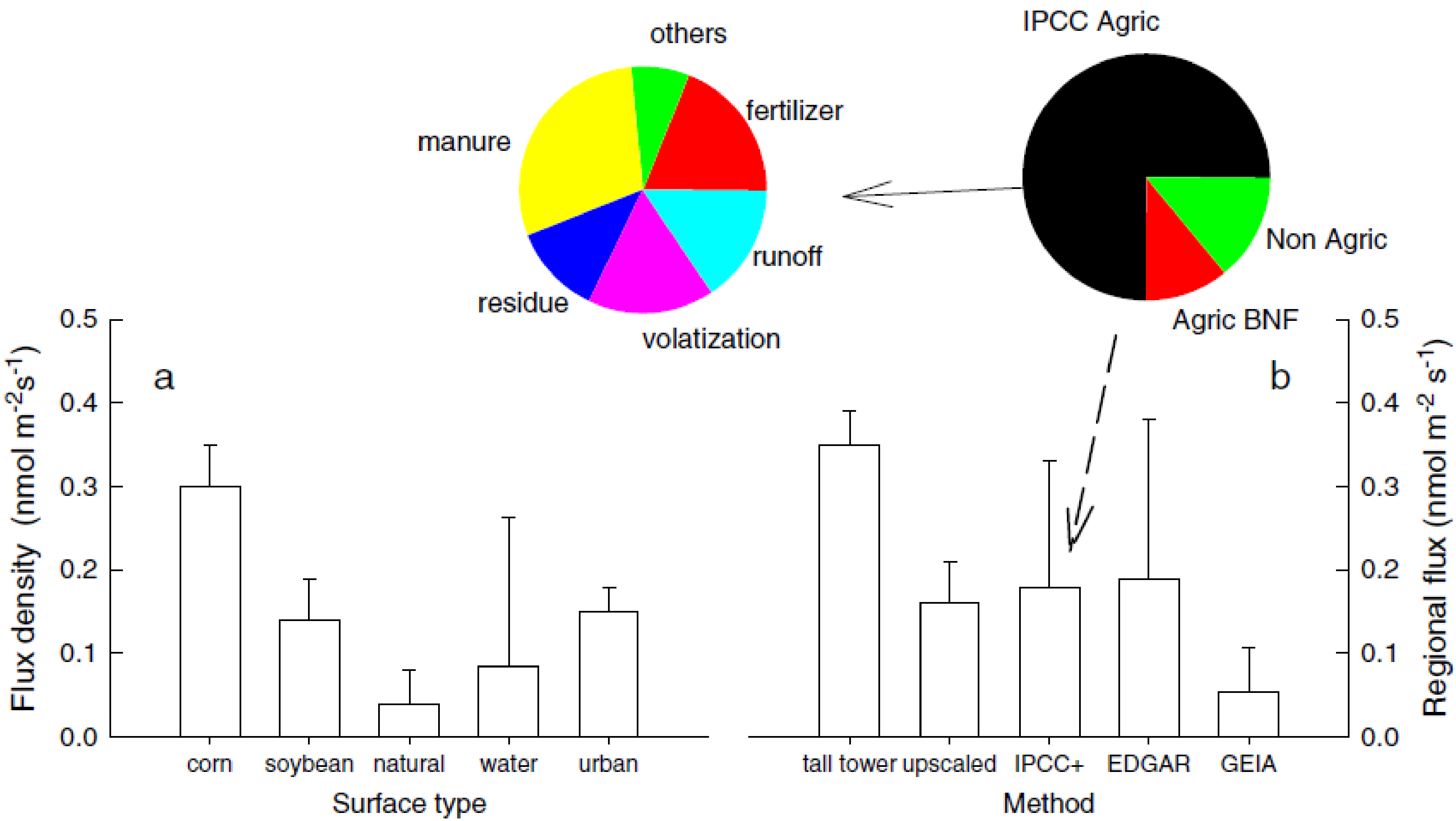

Figure 9. Comparison of N_2O flux densities. (a) Annual mean flux density for the surface types in the tall tower footprint. (b) Comparison of regional flux estimates using different methods.

Conclusion

1. The top-down estimates were approximately 2.6- to 8.8-fold greater than bottom-up approaches (IPCC, EDGAR, and GEIA) and supports previous conclusions.

2. The N_2O budget estimated by the top-down (global) EF of 4.5% was good agreement with the tall tower regional budget assessment.

3. These analyses, combinating with chamber observations from fine-scale agricultural drainage features, suggest that indirect emissions are poorly constrained by the bottom-up approaches.

thank you