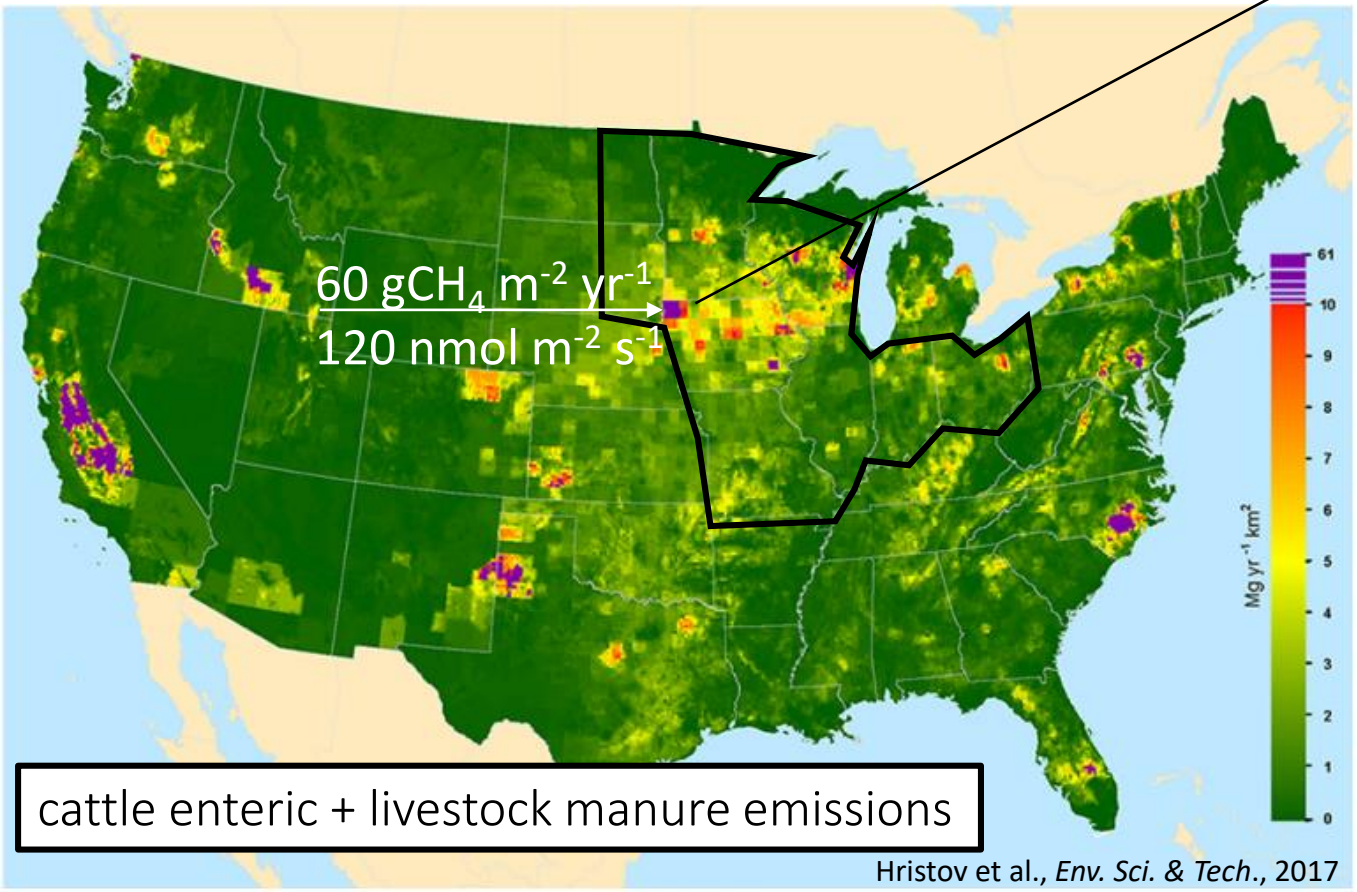
Greenhouse Gas Emissions in the Midwest

GEM TEAM

- Tim Griffis, Xiang Li, Zichong Chen, M. **Julian Deventer** (Biomet, UMN)
- Dylan Millet, Kelley Wells, Xueying Yu (Atmoschem, UMN)
- Alfredo DiConstanzo (Animal Science, UMN)
- Jeffrey Wood (U Missouri)
- Randall Kolka, Tyler Roman (US Forest Service)
- Stephen Conley & Crew (Scientific Aviation)

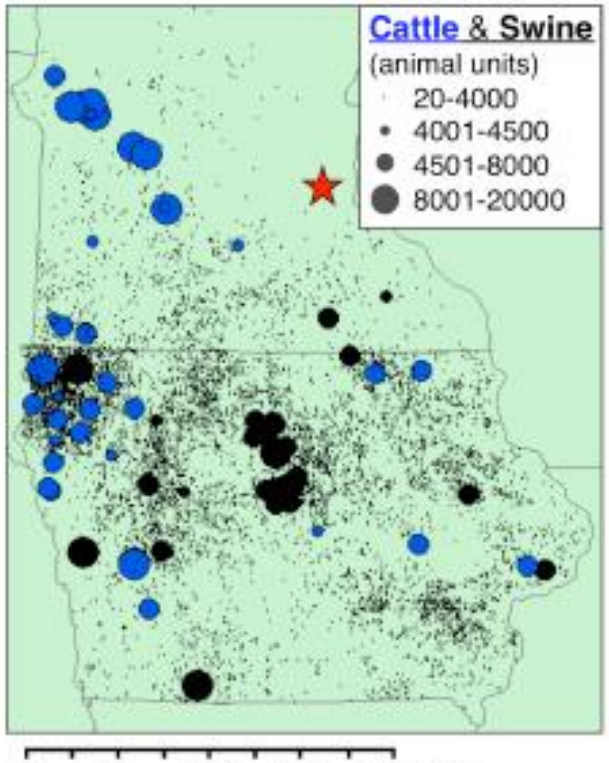
CH_4 from the Midwest Region

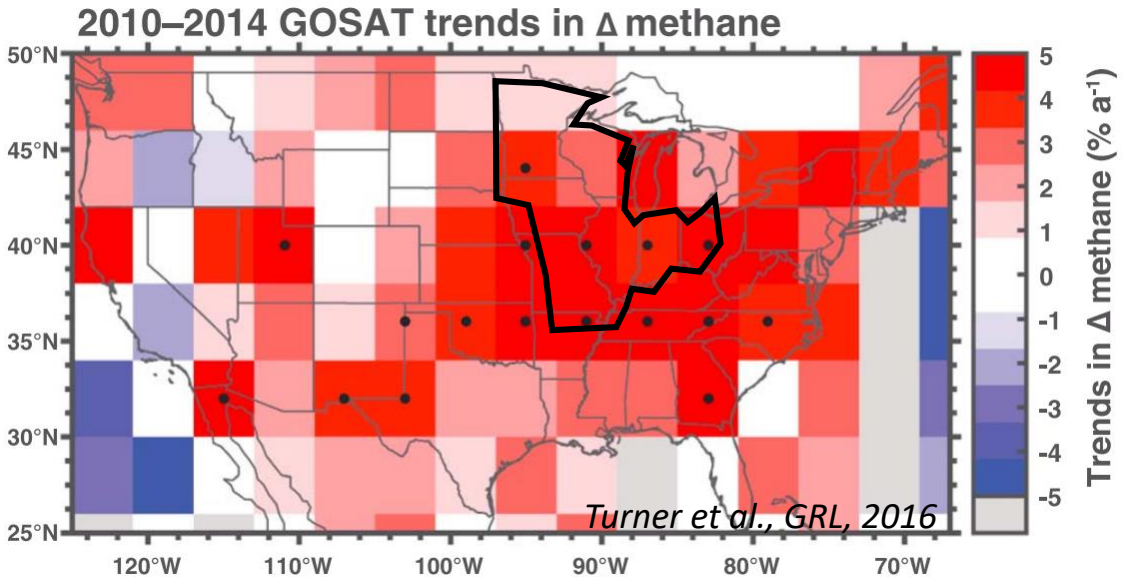
- Nationwide hotspots for livestock/agriculture & natural wetlands
- 700 x 10^6 animals
- 60 x 10^6 humans
- > 40% land cover is agriculture



cattle enteric + livestock manure emissions

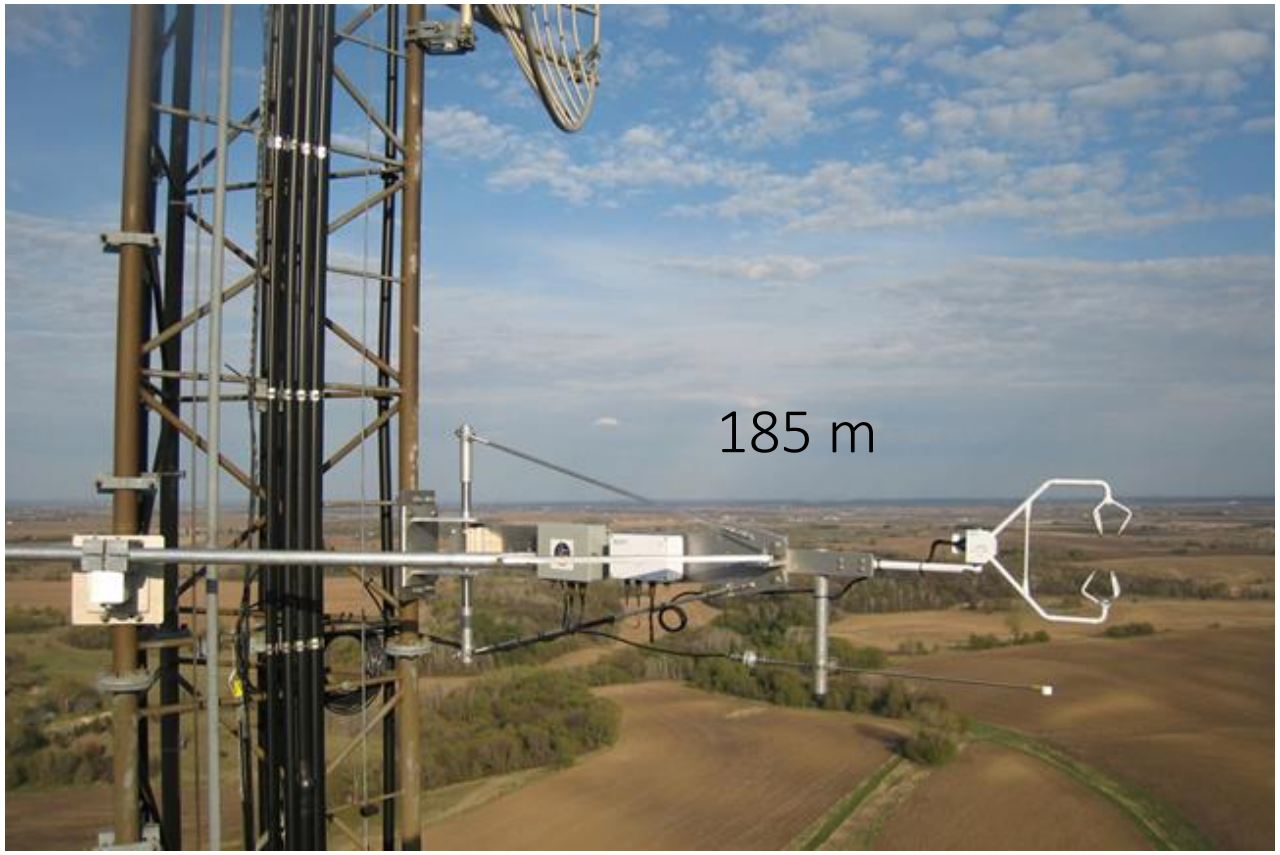
Hristov et al., *Env. Sci. & Tech.*, 2017





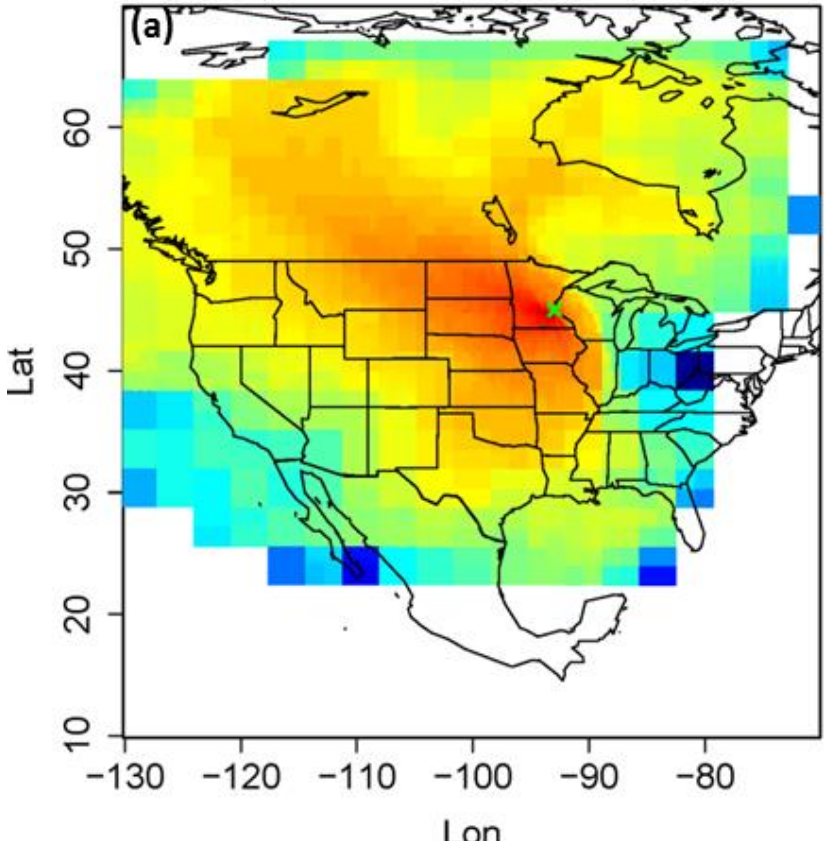
GEM Targets:

- What is the regional CH_4 flux?
- What are seasonal magnitudes?
- What controls CH_4 emitting processes?
- What are the regional sources?



GREENHOUSE GAS EMISSIONS IN THE MIDWEST

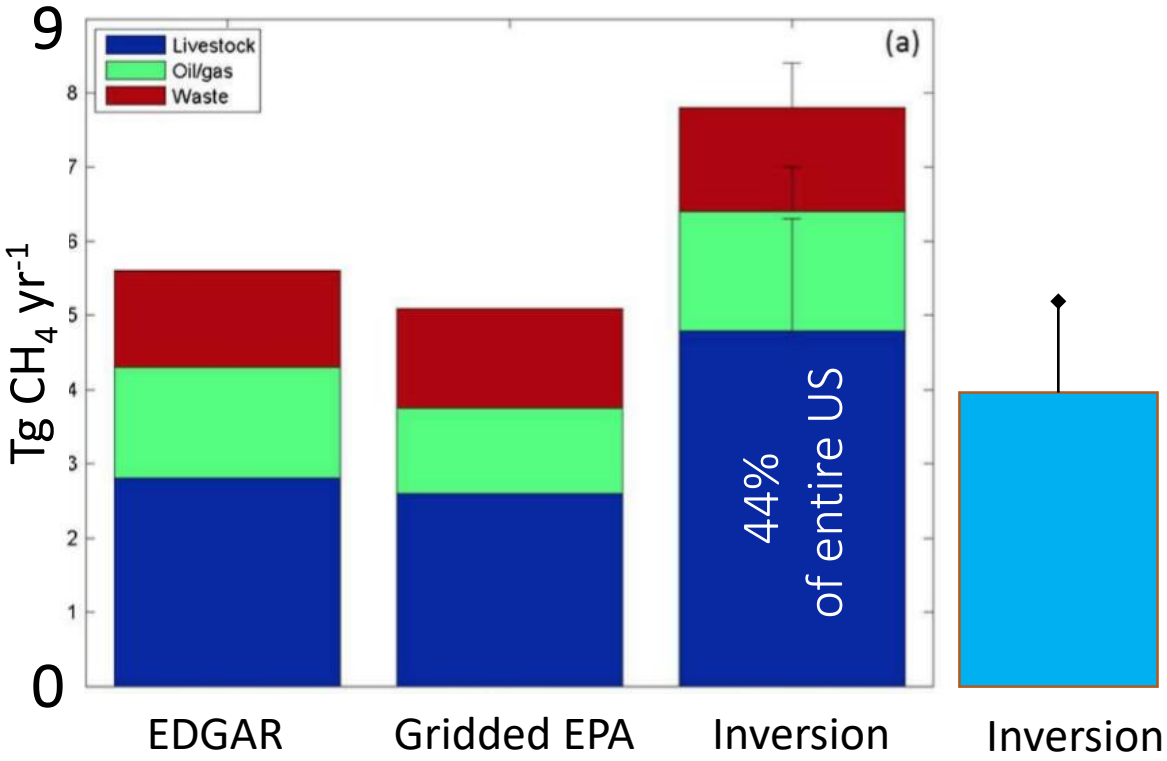
UMN Tall Tower footprint contribution map (WRF-STILT)



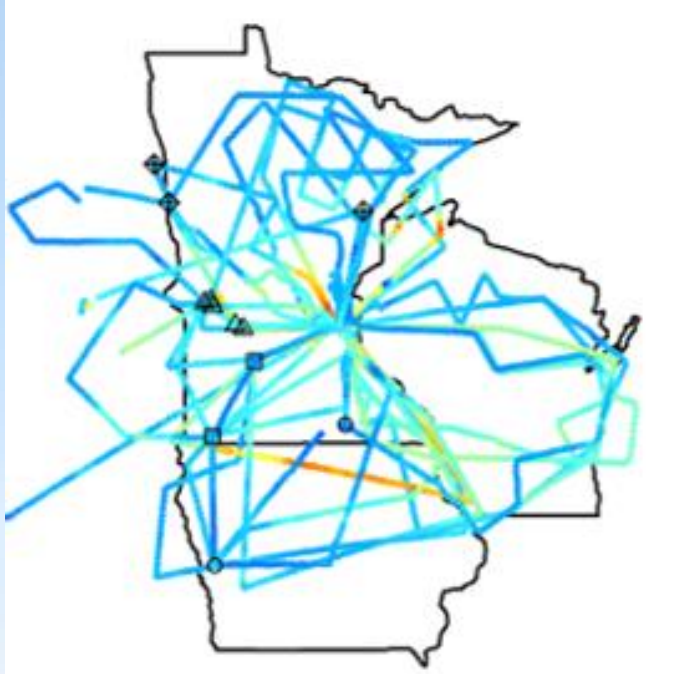
Bayesian Inversion studies by **Zichong Chen**
AGU: B21K-0330, Tues 08-12
Chen et al.(2018) J Geophys Res Biogeosci

The Regional Budget – Scale Factor Bayesian Inverse

- Regional flux 10-30 nmol m^{-2} s^{-1} = 22% of total US budget
- Increase livestock emissions x 1.8 as compared to a-priori (bottom ups)



Surveying Point Sources – Airborne flux measurements

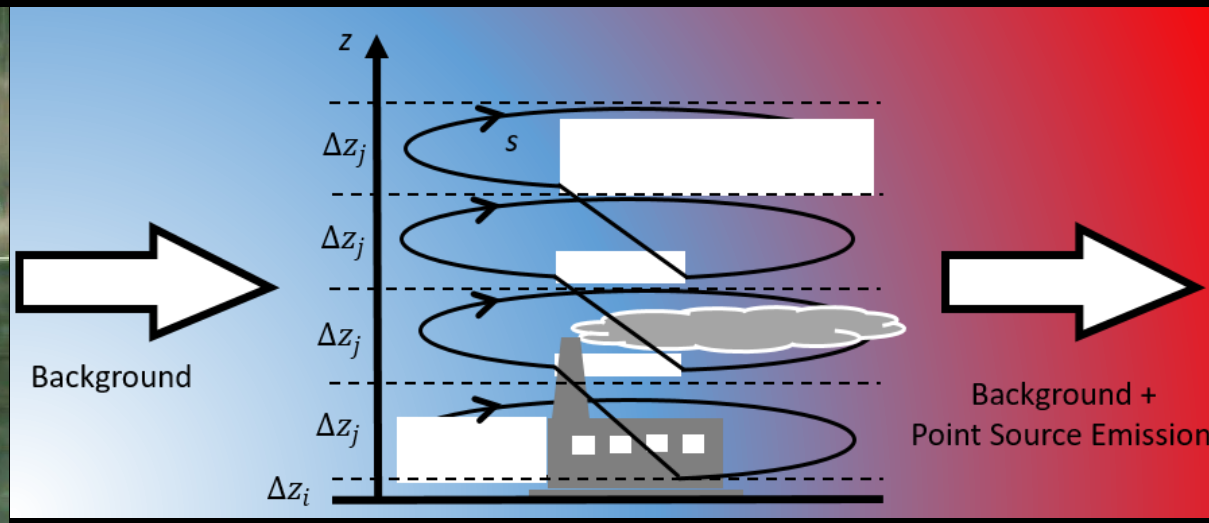


The following slides show preliminary results
Absolute values might change in future work

Facility scale: A closer look

Top down aircraft flux measurements **Xueying Yu**

AGU: B44D-06, Thurs, 16-18



Flux = sum (of advected $\Delta\ CH4$ per layer times height)

Dairy:

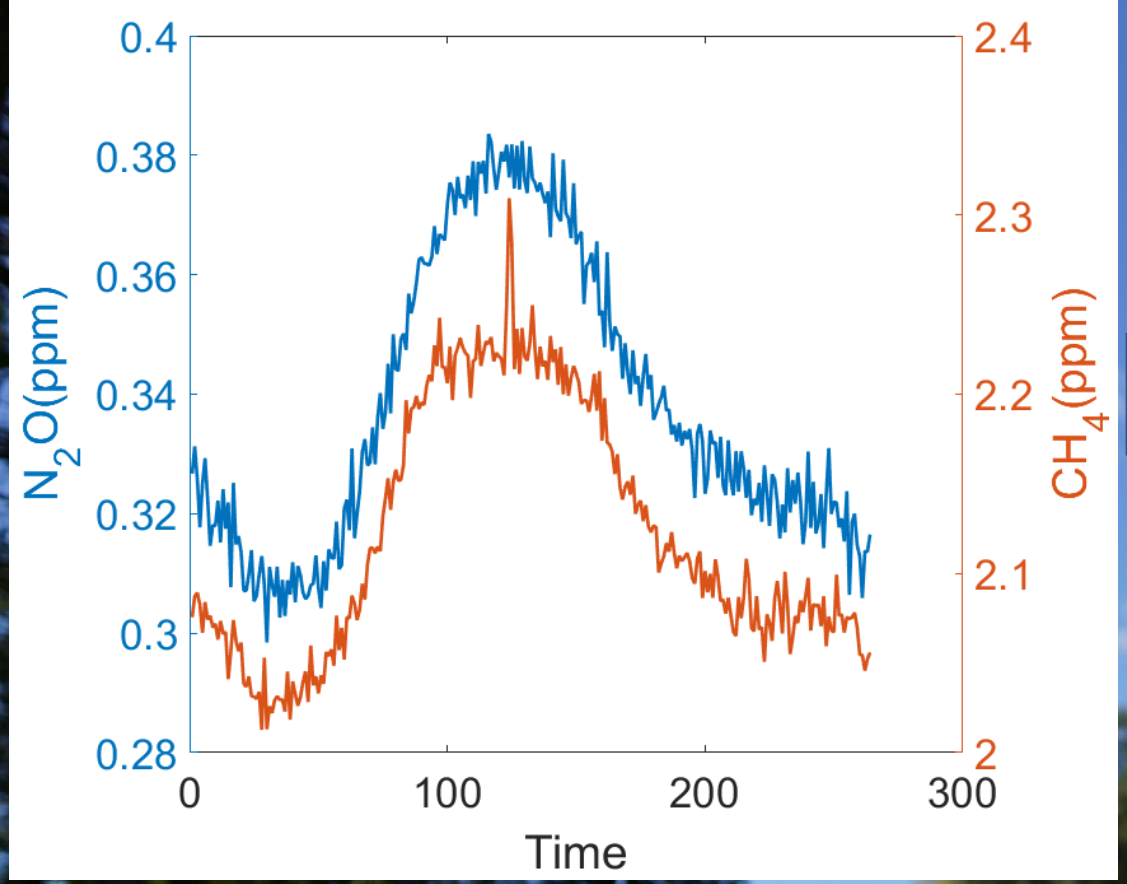
- Aircraft EF = 130 kg yr^{-1} $head^{-1}$
- EPA EF = 210 kg yr^{-1} $head^{-1}$

Beef:

- Good agreement

Facility Scale Flux by Tracer Release and Dispersion Modeling Study

Xiang Li (AGU: B41H-0296, Thurs 08-12)



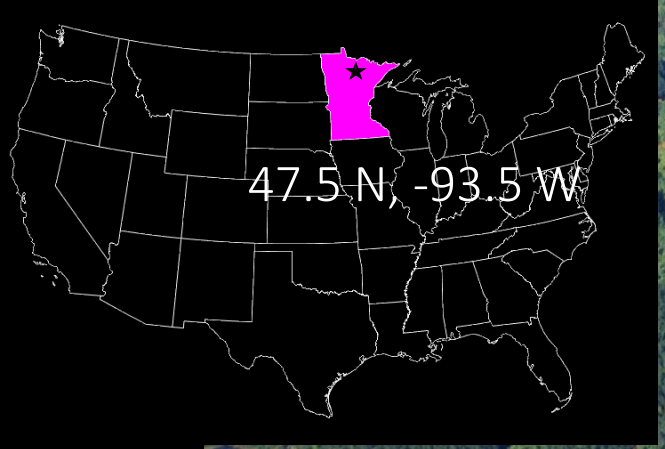
F CH_4 = unknown

F N_2O= known

$$\frac{\Delta[CH_4]}{\Delta[N_2O]} = \frac{F_{CH4}}{F_{N2O}}$$

Local flux: 20 μmol m^{-2} s^{-1}

= 10 kg m^{-2} yr^{-1}

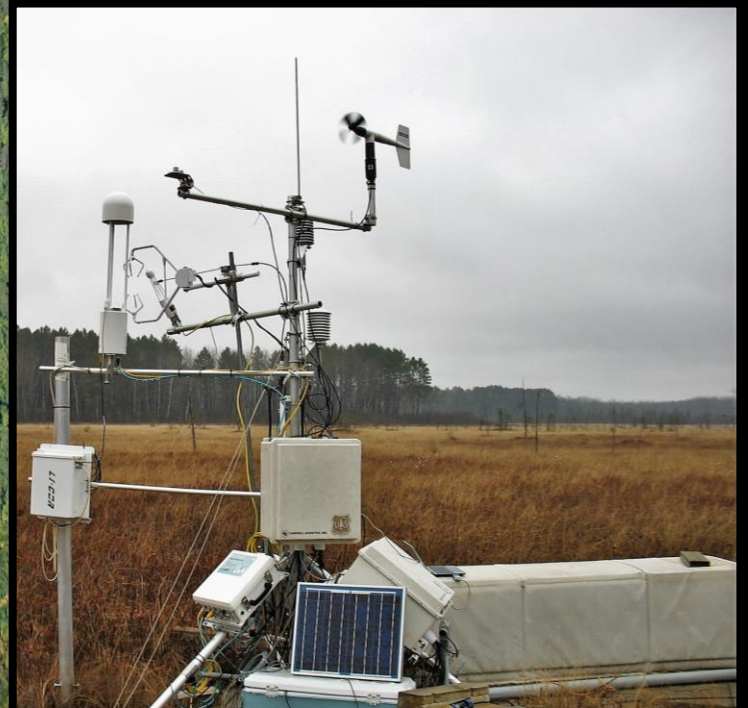


- Poorly minerotrophic to oligotrophic fen
- *Sphagnum* derived peat ≈ 3 m depth

- closed path CH_4 measurements since 2009 – TGA
- open path CH_4 measurements since 2015 – Li7700

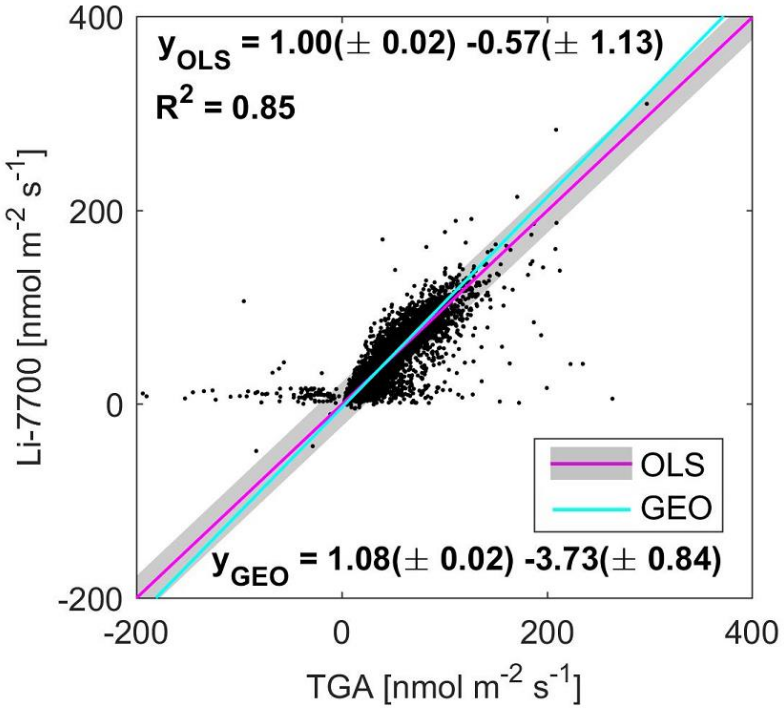
"Bog Lake Fen"

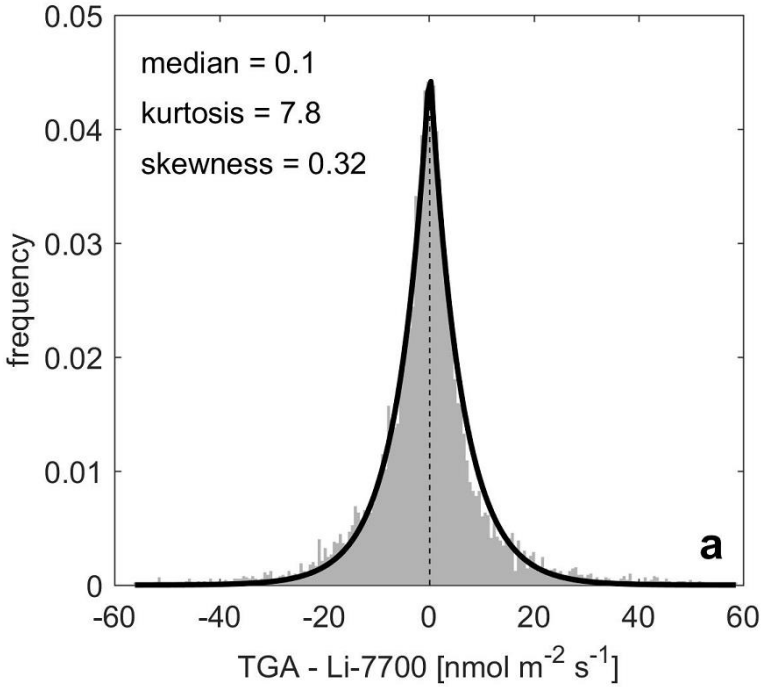
Mean annual Tair = 3°C

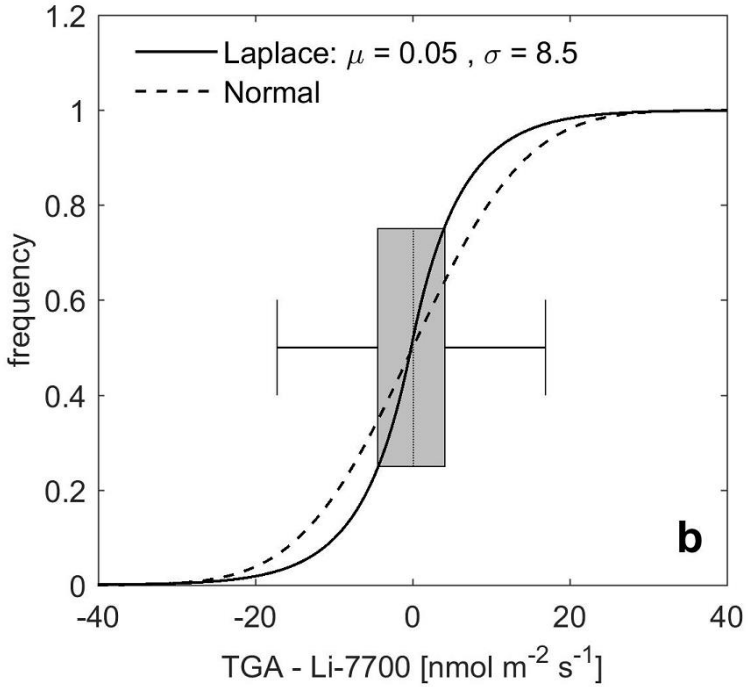


Flux Uncertainty

- Replication approach: IQR = 8 nmol m^{-2} s^{-1}, σ^2 = 8.5 nmol m^{-2} s^{-1} , median ≤ +0.1
- Stochastic approach: median = 4 ± 2 (IQR) nmol m^{-2} s^{-1} , Finkelstein & Sims (2001)







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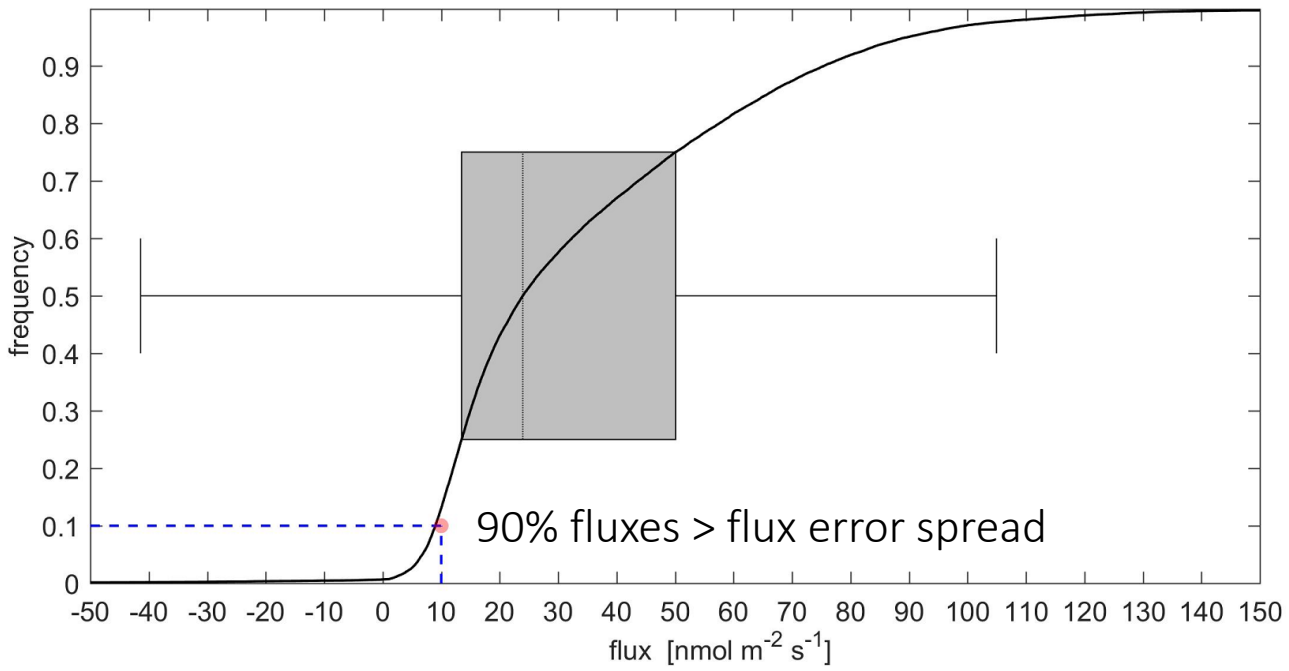
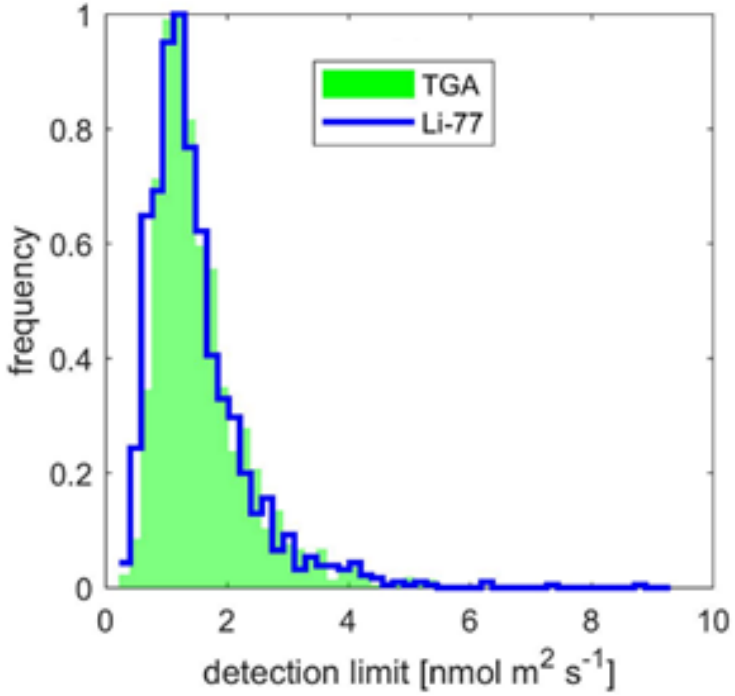
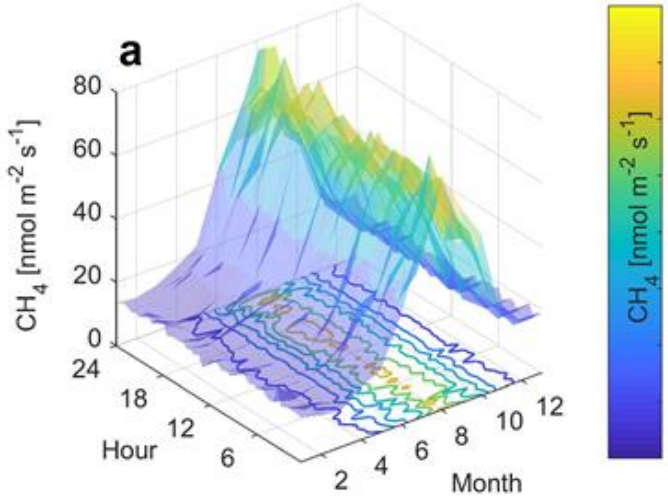


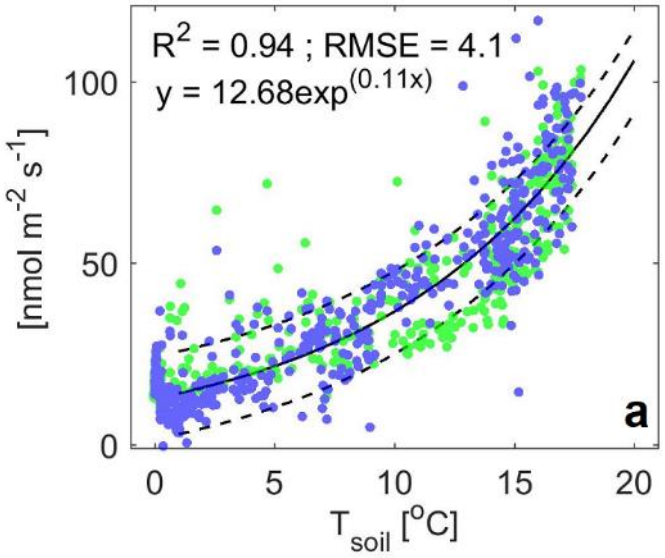


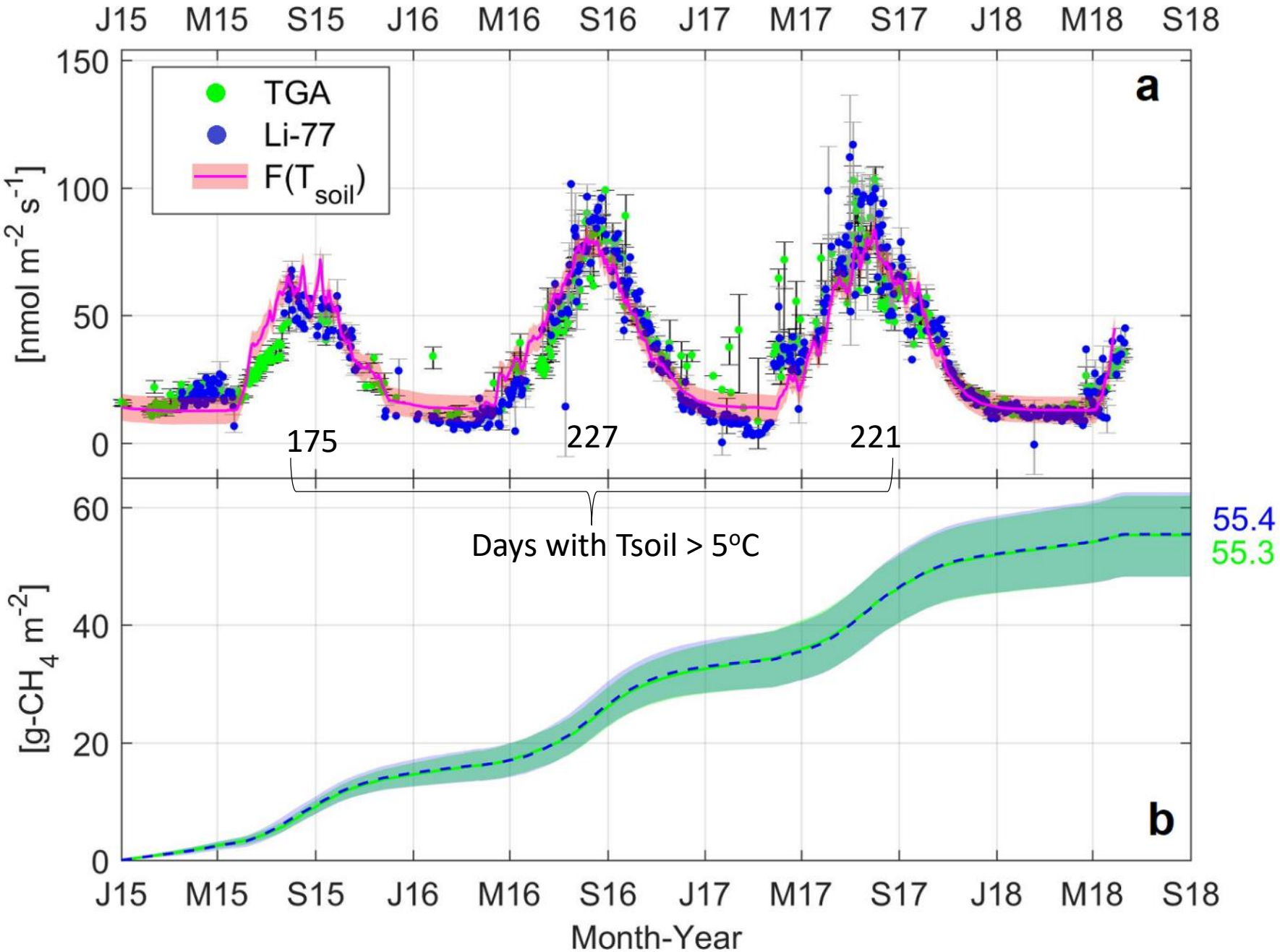
Wienhold et al (1995):
$\sigma(xcov_{wc})$

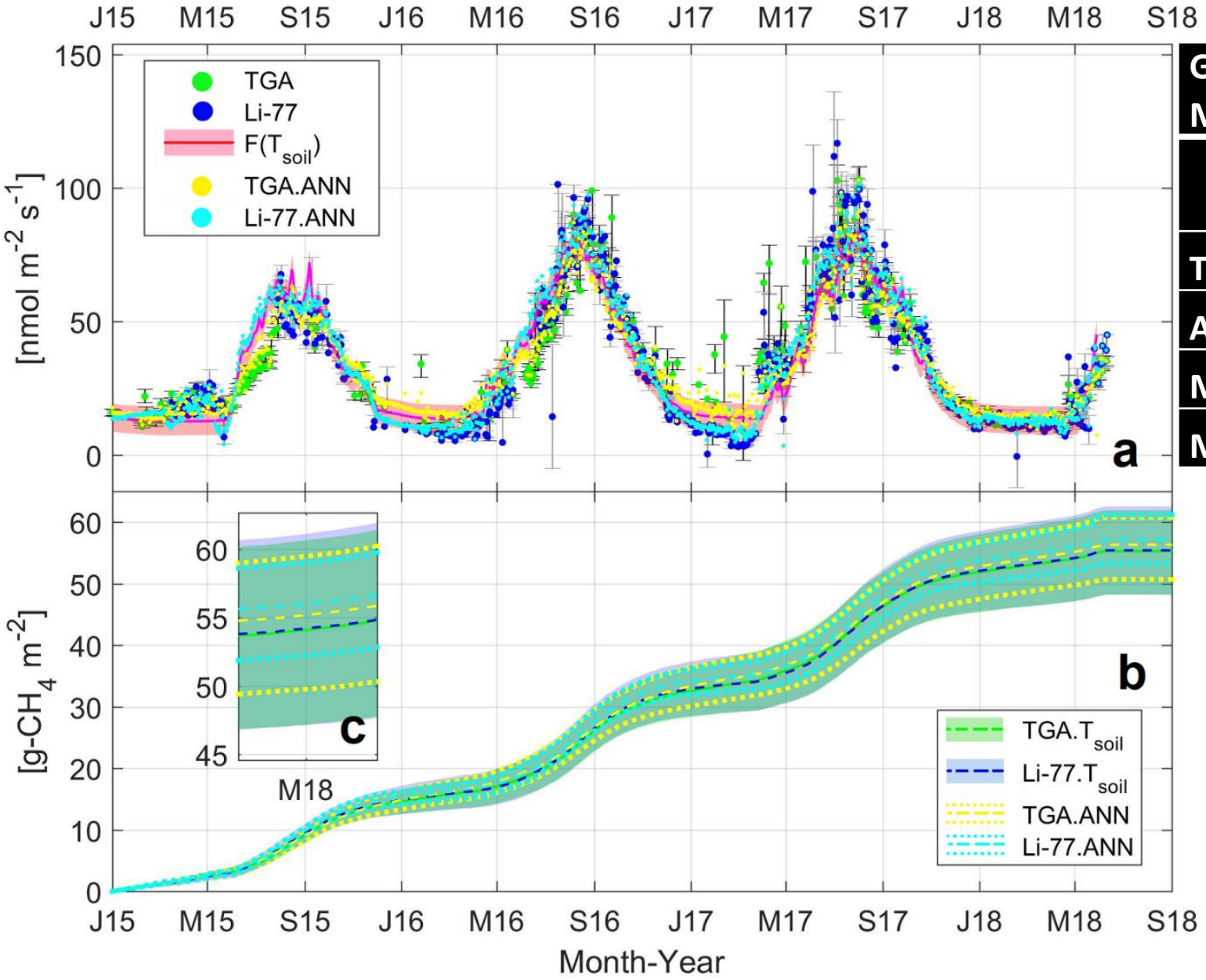
marginal diurnal variation



Q10 ≈ 3







Gap-Fill Method	Sensor	
	TGA-100 [g-CH_4 m^{-2}]	Li-7700 [g-CH_4 m^{-2}]
Tsoil	55.3 [48.2, 61.9]	55.4 [48.1, 62.5]
ANN	56.3 [48.3, 62.0]	57.2 [48.2, 65.6]
MDC	56.4	54.7
MDC & LUT	55.6	55.2

mean annual emission of

16.5 ± 4.2 g-CH_4 m^{-2} yr^{-1}

≈ 25% Flux Uncertainty

Uncertainty matters:

is 2017 statistically > 2016?