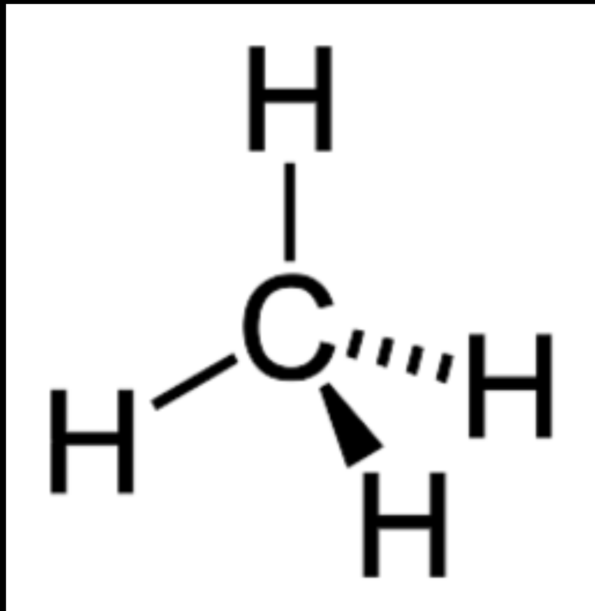
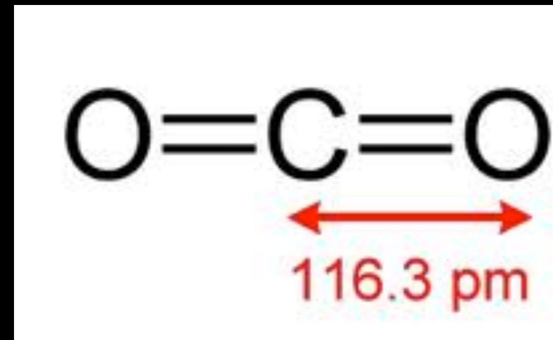
Is Methane Interesting?

Ankur R Desai
University of Wisconsin

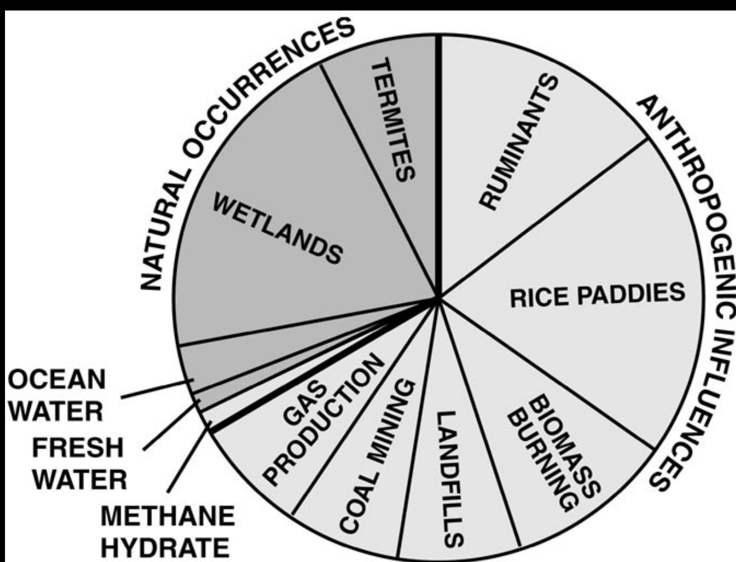
http://purefixion.com/attention/2006/03/cow-farts.html

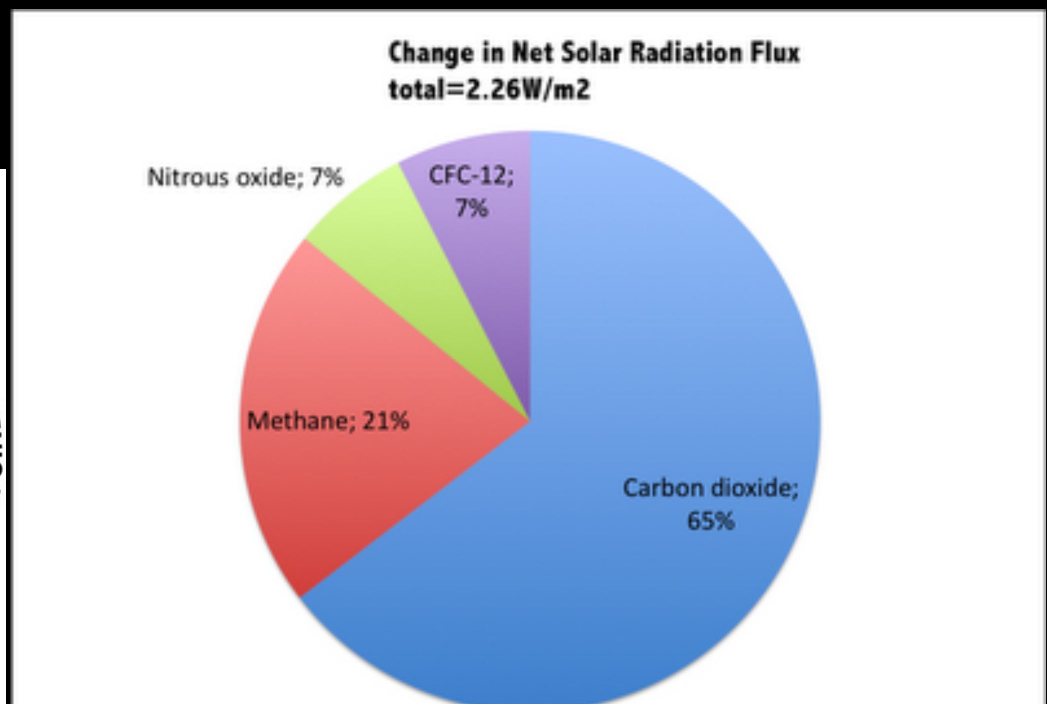


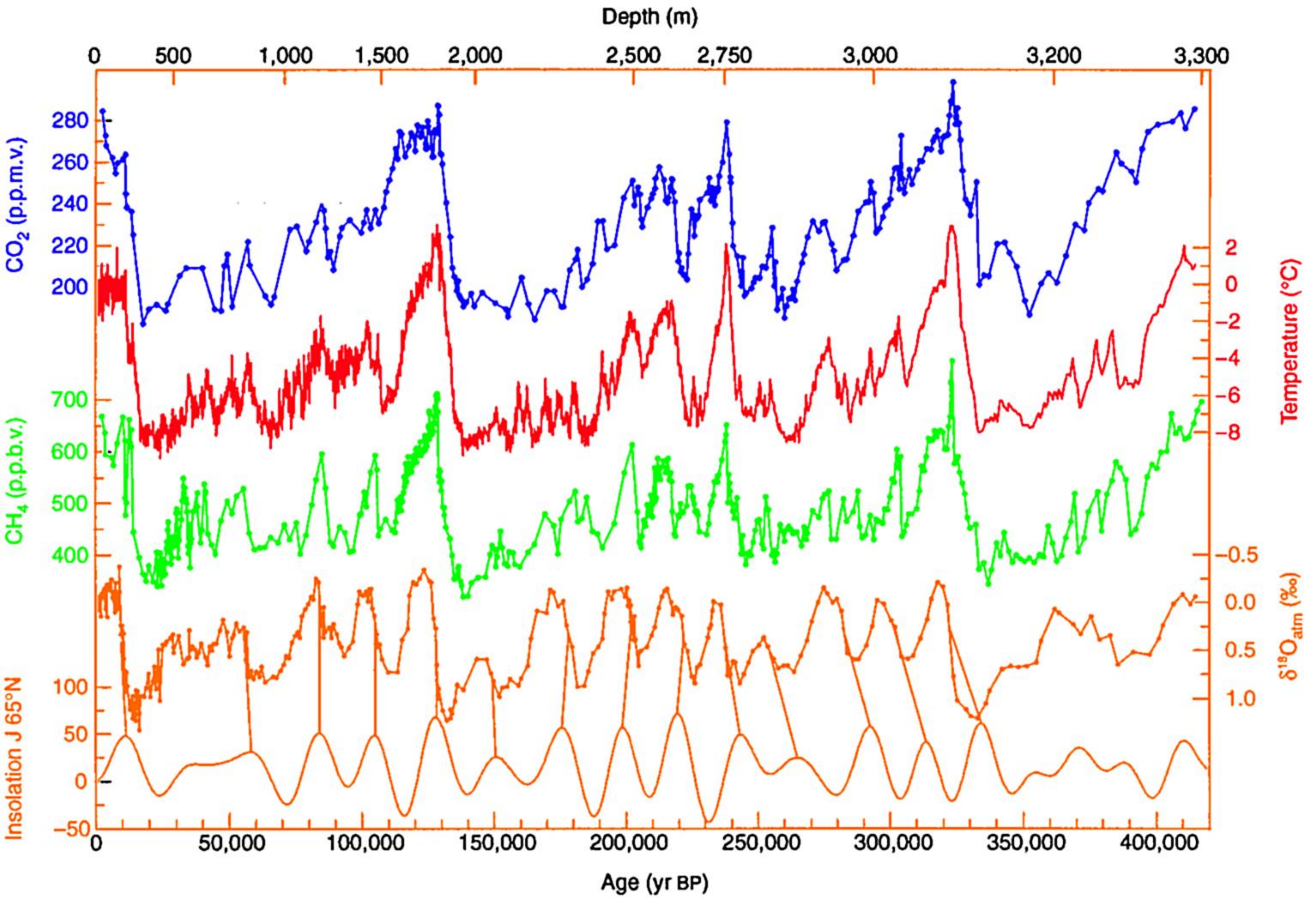


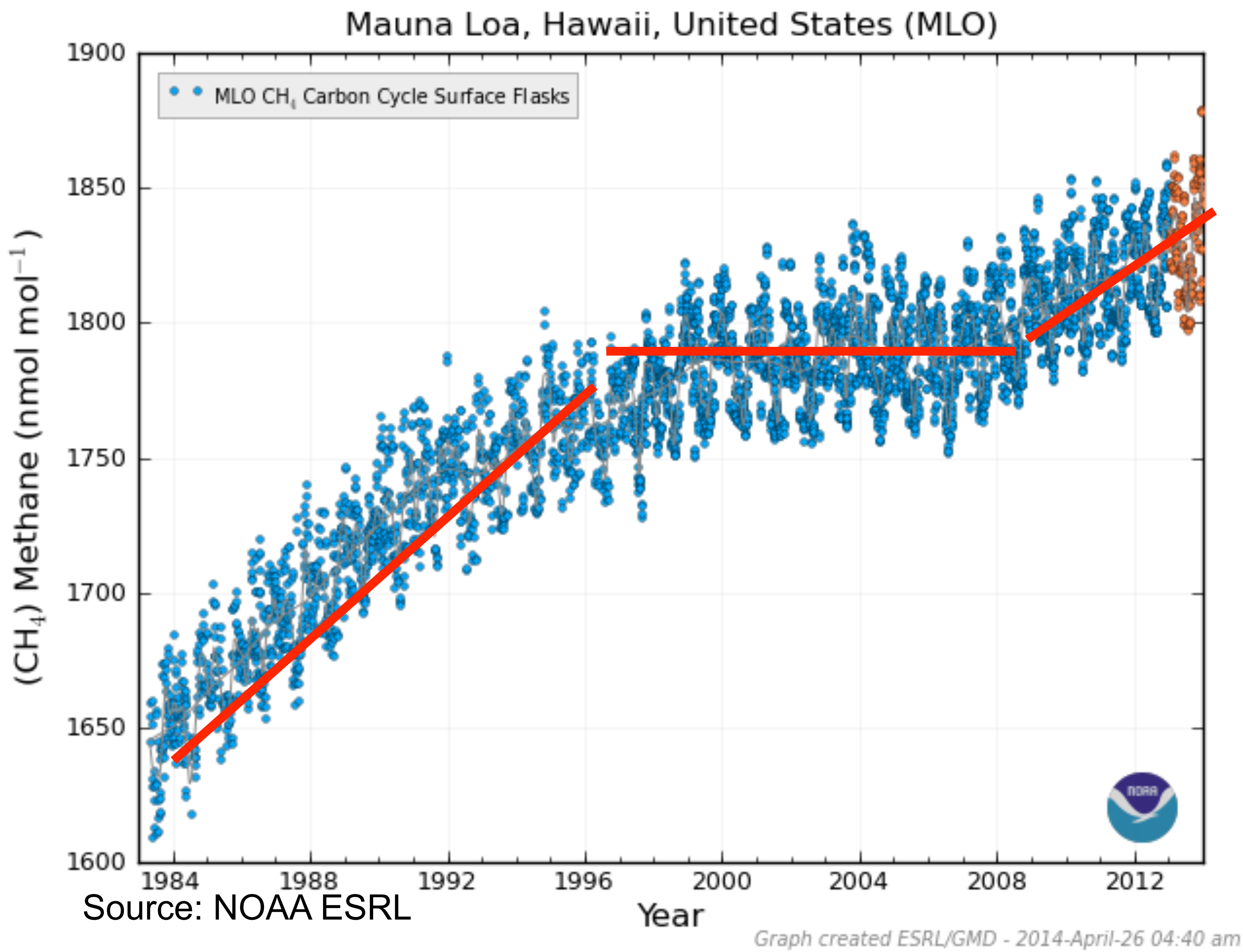
Carbon Dioxide
400 ppm
30-100+ years

Methane
1.8 ppm
Atmos lifetime ~10 yrs

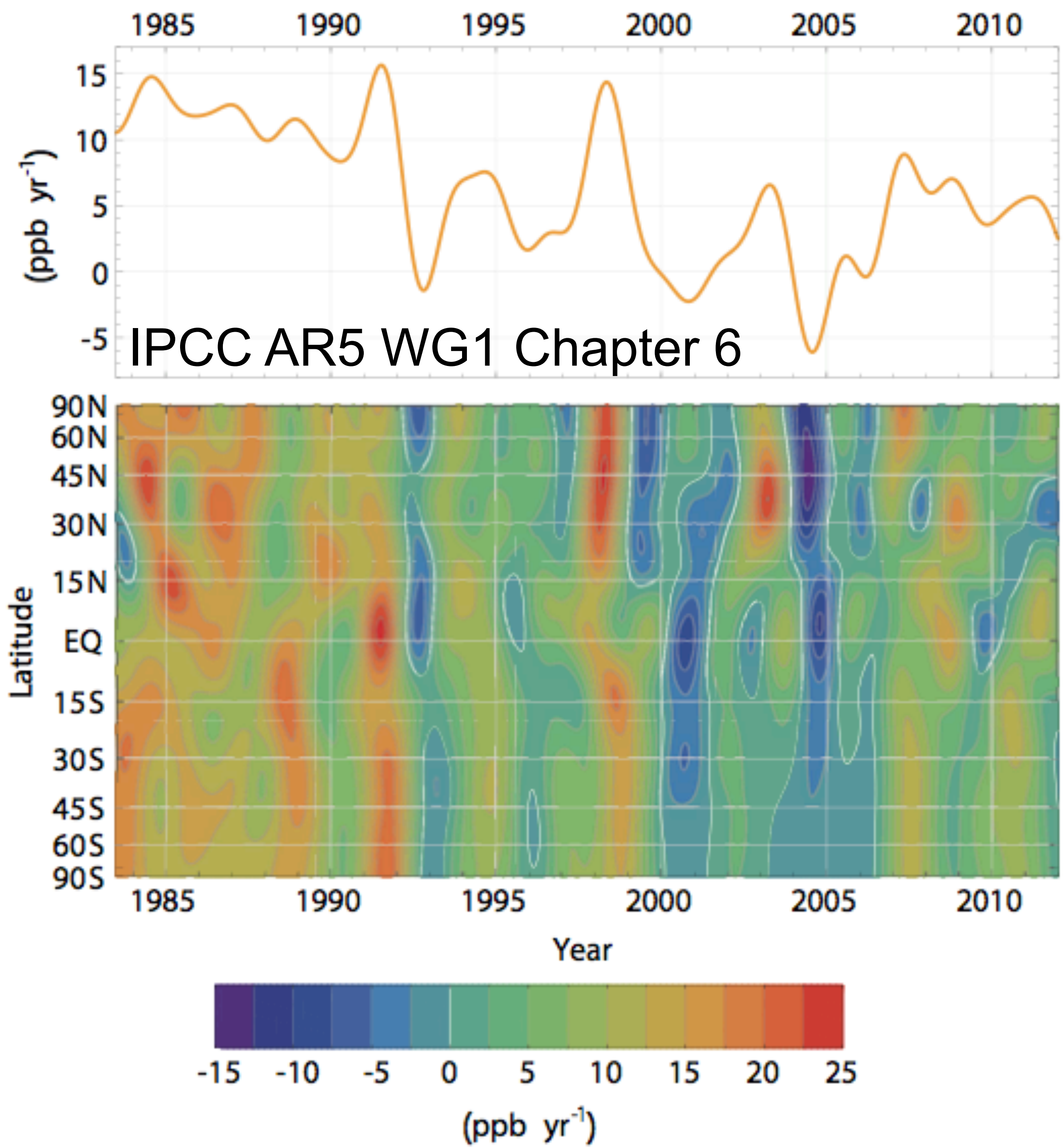


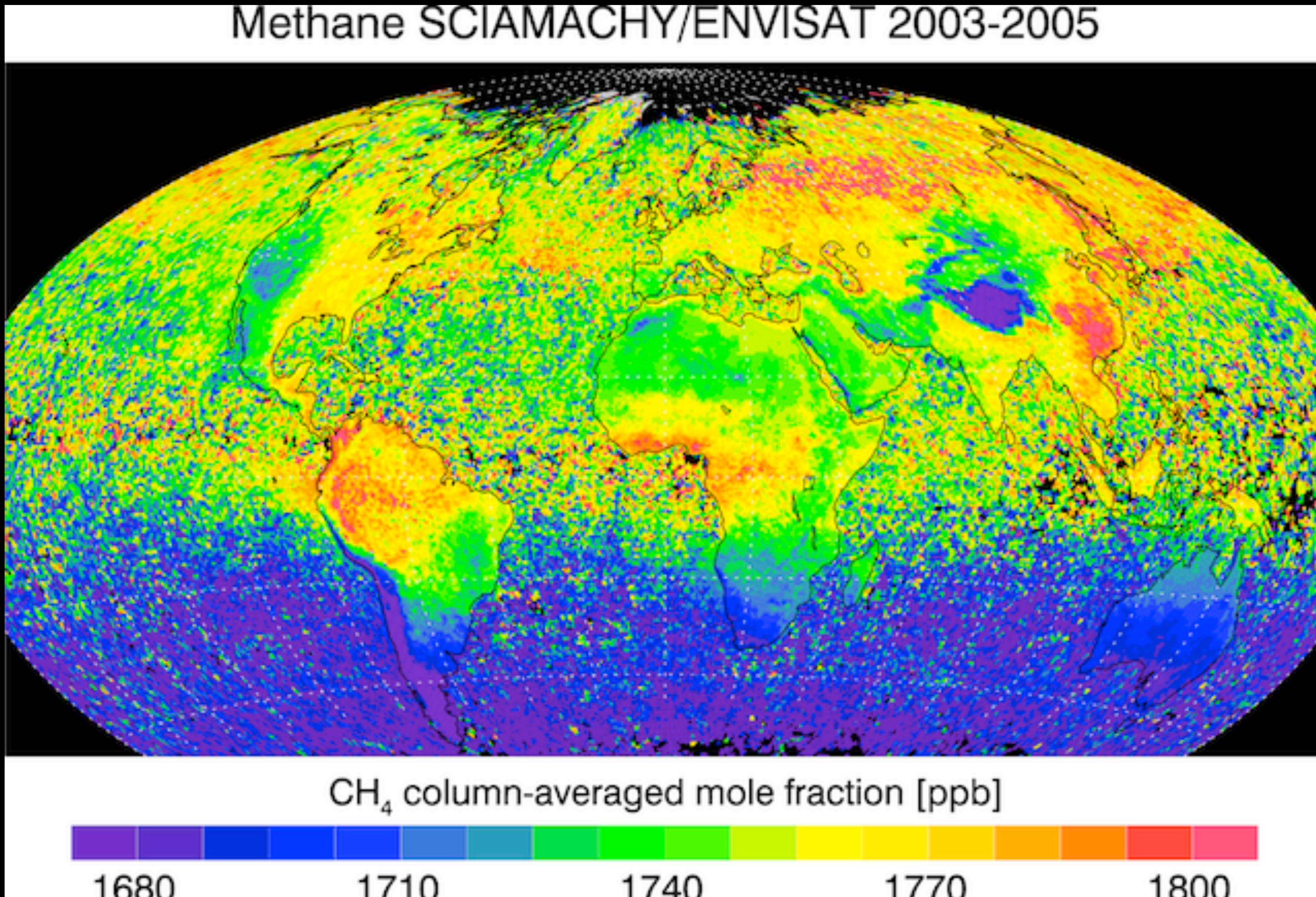



Depth (m)
0
500
1,000
1,500
2,000
2,500
2,750
3,000
3,200
3,300
CO2 (p.p.m.v.)
280
260
240
220
200
Temperature (°C)
2
0
−2
−4
−6
−8
CH4 (p.p.b.v.)
700
600
500
400
δ18Oatm (‰)
−0.5
0.0
0.5
1.0
Insolation J 65°N
100
50
0
−50
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
Age (yr BP)

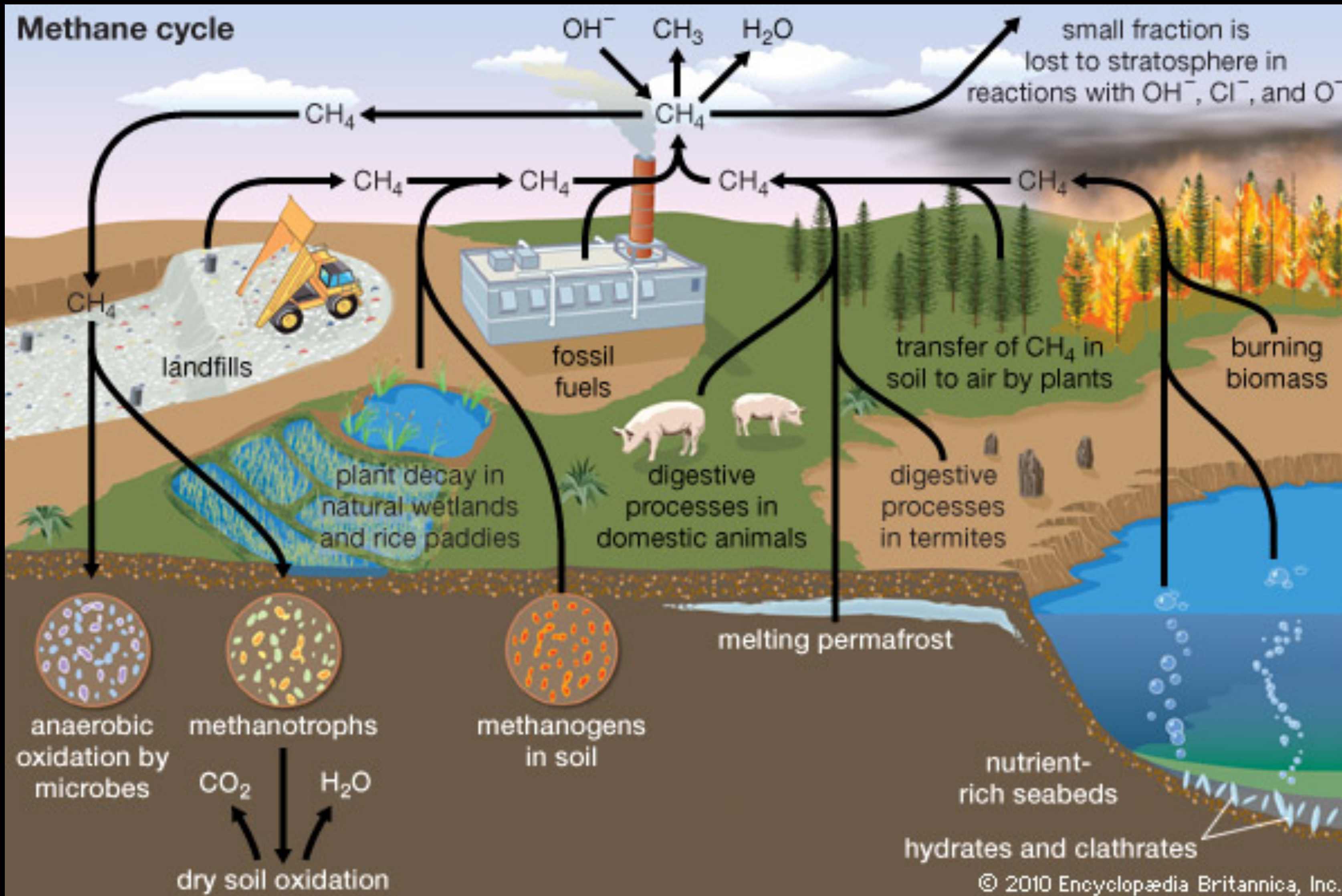


Source: NOAA ESRL

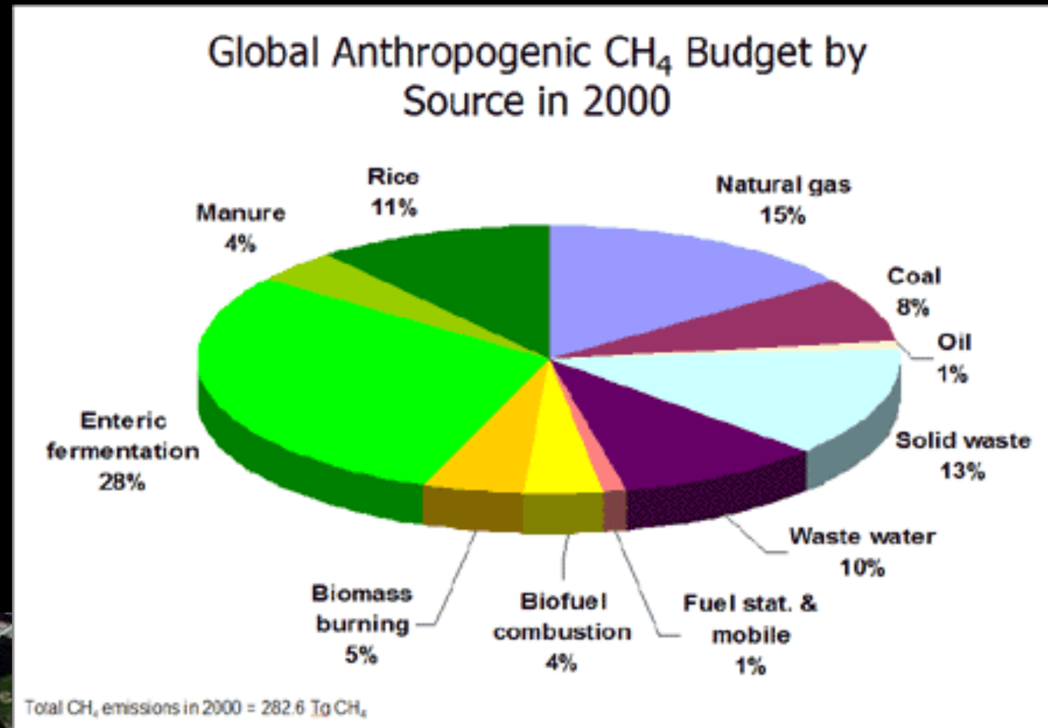

IPCC AR5 WG1 Chapter 6
1985
1990
1995
2000
2005
2010
15
10
5
0
-5
(ppb yr-1)
90N
60N
45N
30N
15N
EQ
15S
30S
45S
60S
90S
Latitude
Year
-15
-10
-5
0
5
10
15
20
25
(ppb yr-1)



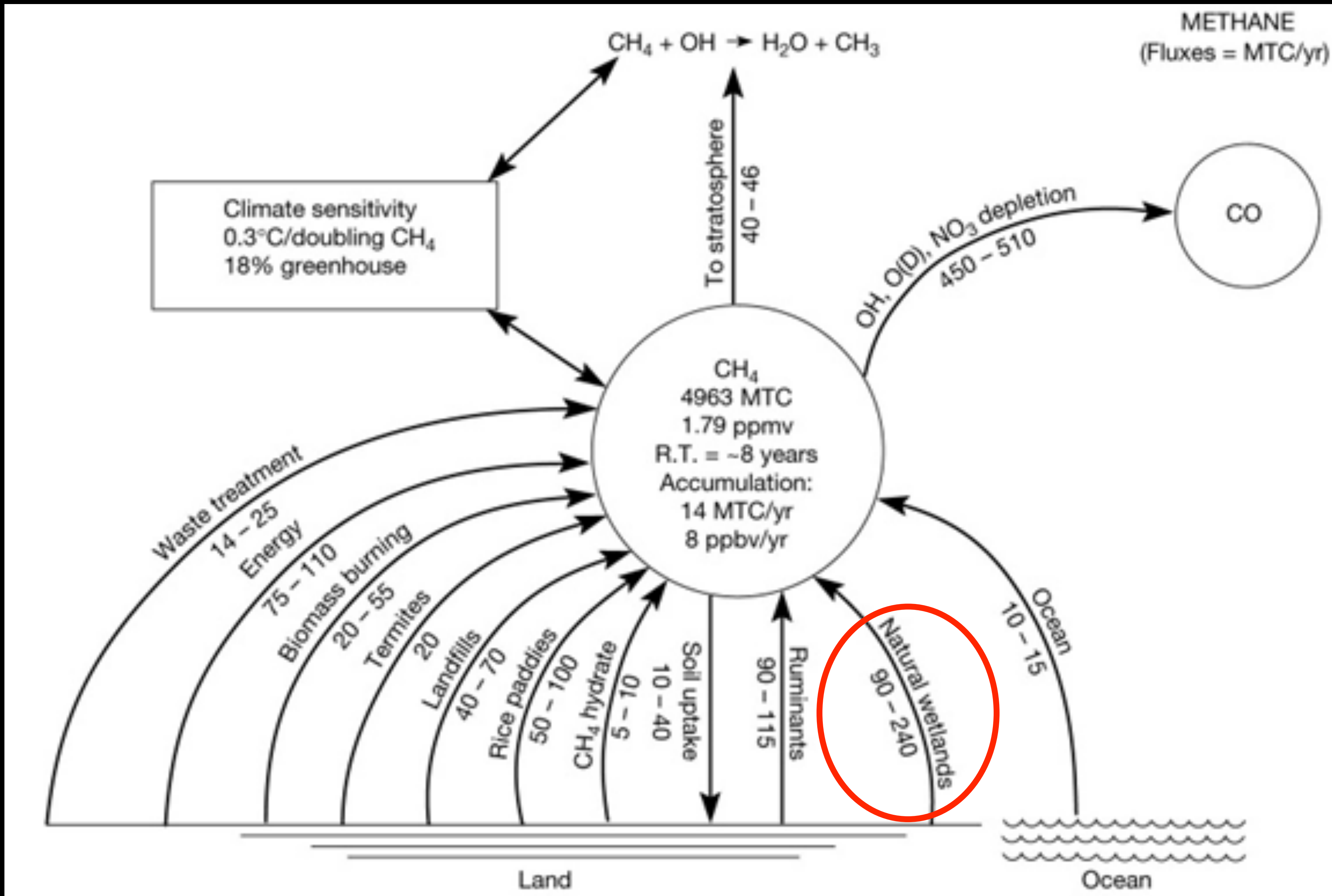
http://www.iup.uni-bremen.de/sciamachy/NIR_NADIR_WFM_DOAS/wfmd_image_gallery_ch4.html



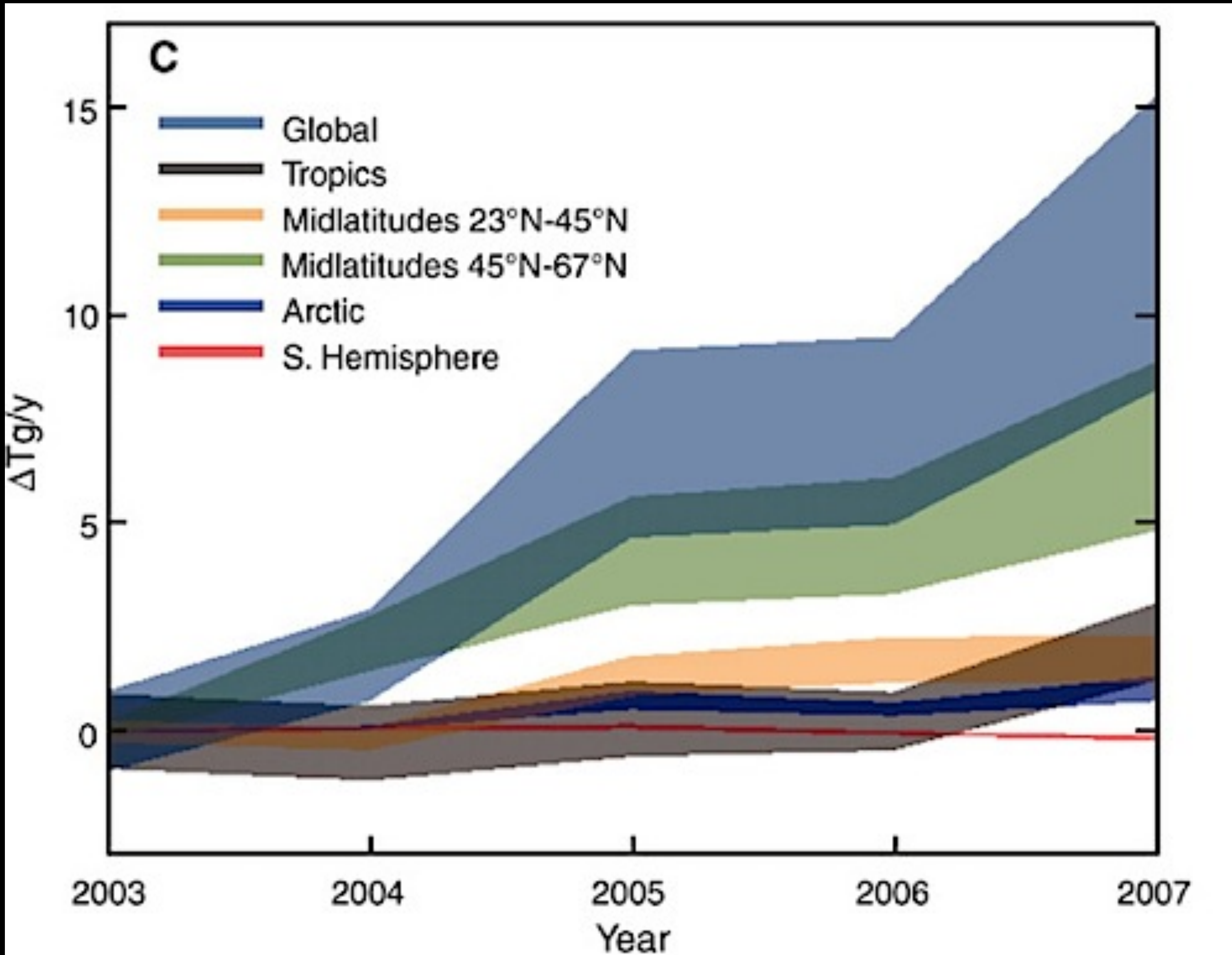
http://media-1.web.britannica.com/eb-media/75/135075-004-105F7745.jpg



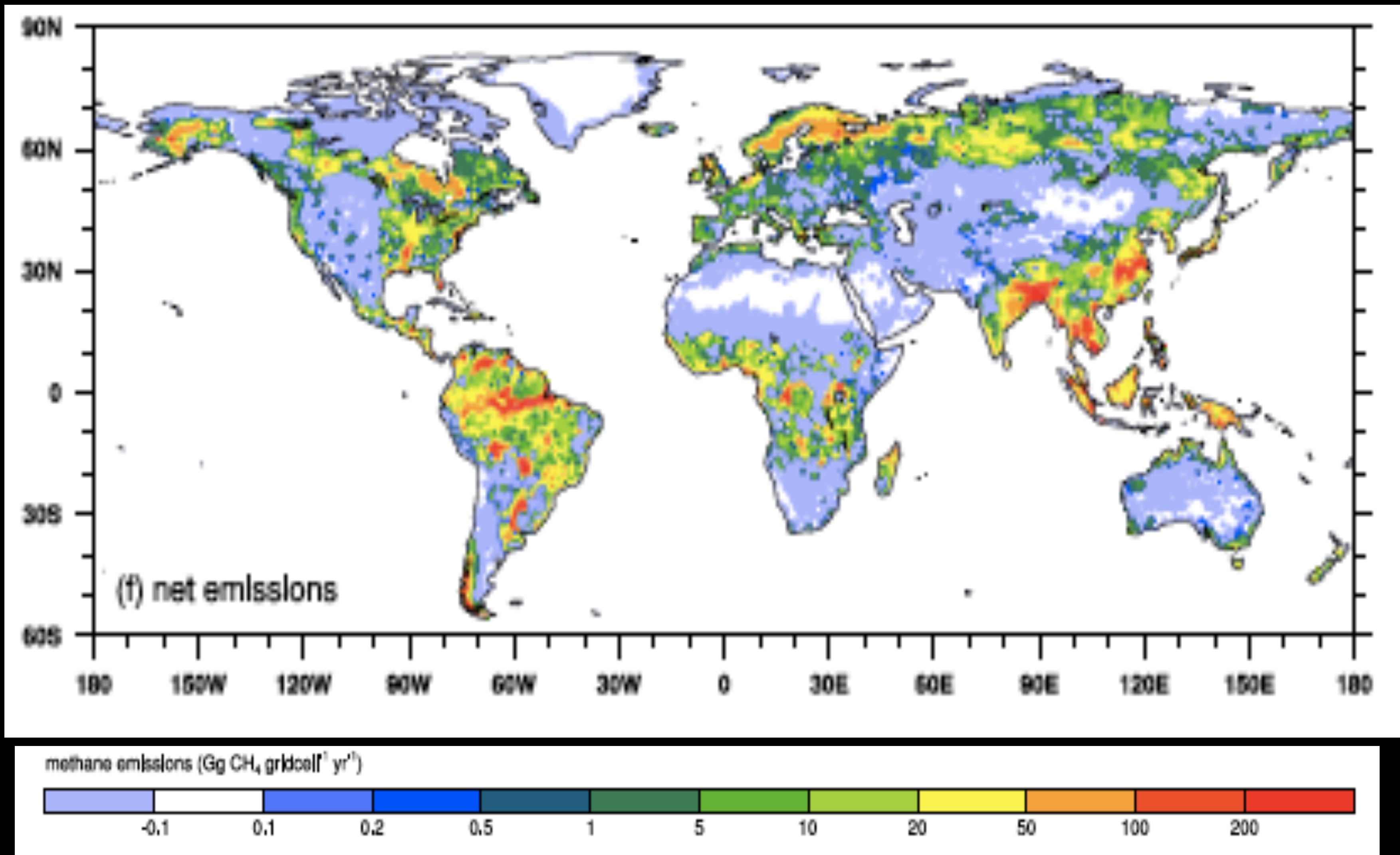
Source: Picarro, Inc. / Nathan Phillips, BU



METHANE
(Fluxes = MTC/yr)
$CH_4 + OH \rightarrow H_2O + CH_3$
Climate sensitivity
0.3°C/doubling CH_4
18% greenhouse
To stratosphere
40 – 46
OH, O(D), NO_3 depletion
450 – 510
CO
CH_4
4963 MTC
1.79 ppmv
R.T. = ~8 years
Accumulation:
14 MTC/yr
8 ppbv/yr
Waste treatment
14 – 25
Energy
75 – 110
Biomass burning
20 – 55
Termites
20
Landfills
40 – 70
Rice paddies
50 – 100
CH_4 hydrate
5 – 10
10 – 40
Soil uptake
90 – 115
Ruminants
Natural wetlands
90 – 240
Ocean
10 – 15
Land
Ocean



Bloom et al., Science, 2010

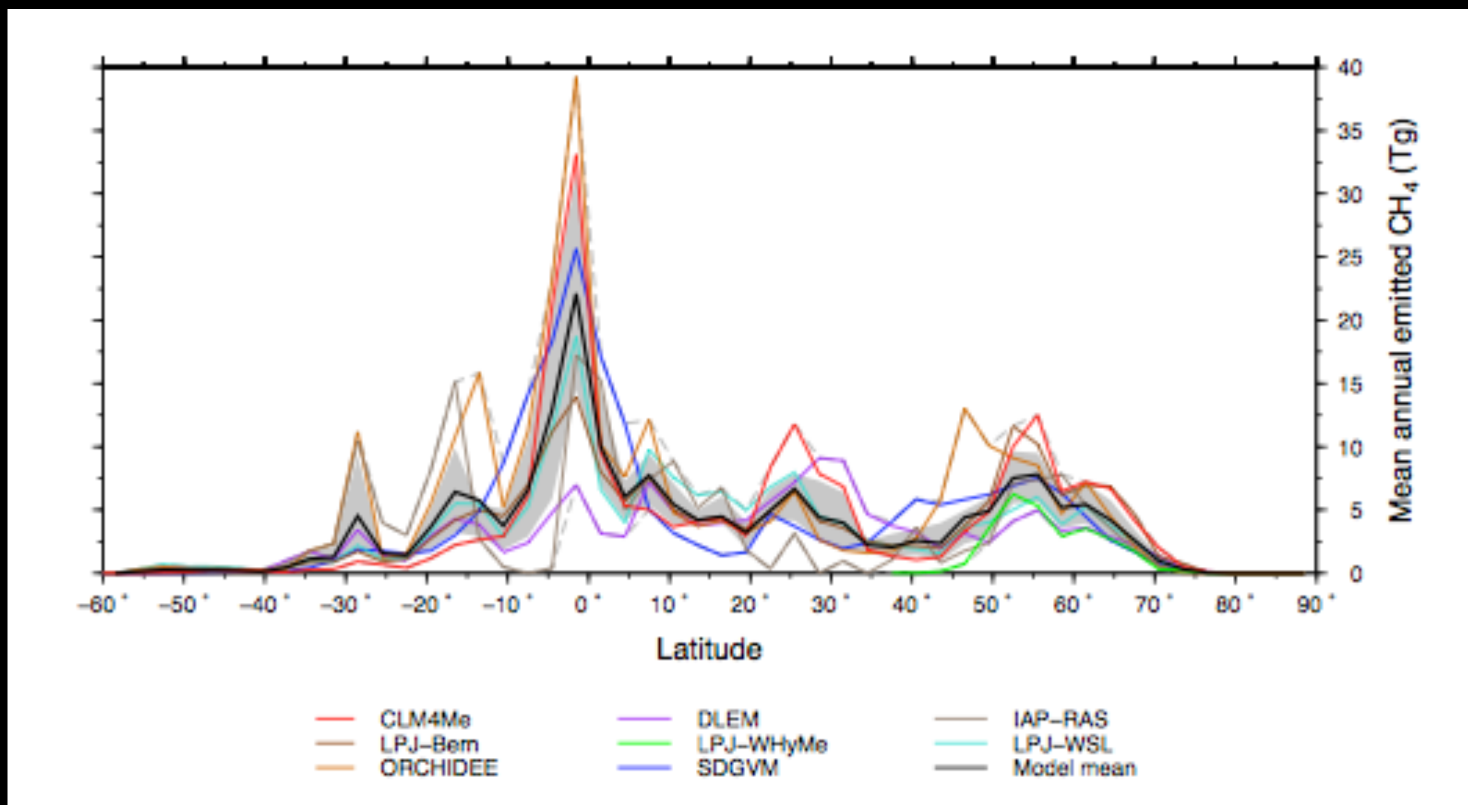


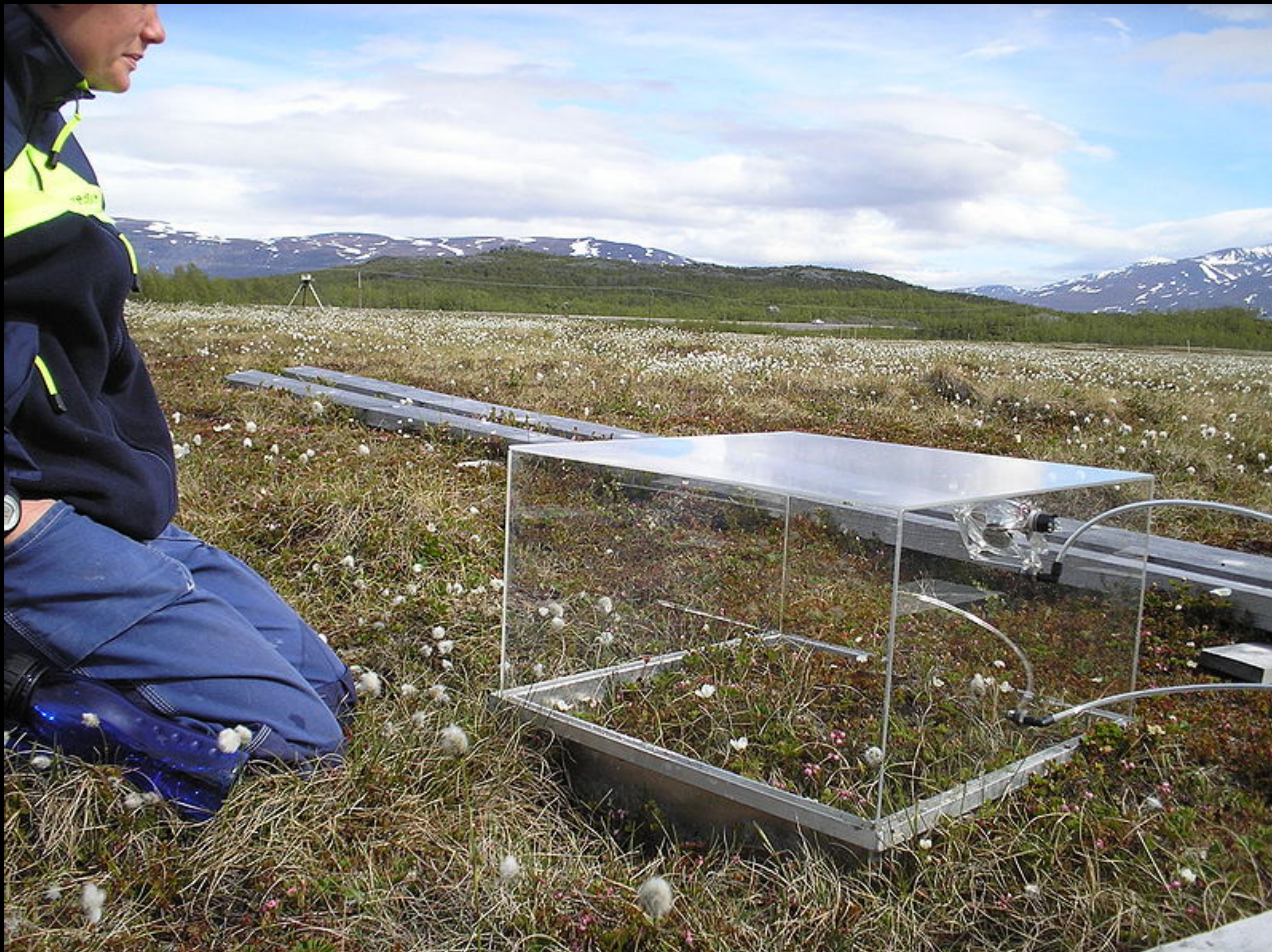
Spahni et al. (2011) Biogeosciences

Present state of global wetland extent and wetland methane modelling: conclusions from a model inter-comparison project (WETCHIMP)

Biogeosciences, 2013

J. R. Melton[1,*], R. Wania[2,**], E. L. Hodson[3,***], B. Poulter[4], B. Ringeval[4,5,6], R. Spahni[7], T. Bohn[8], C. A. Avis[9], D. J. Beerling[10], G. Chen[11], A. V. Eliseev[12,13], S. N. Denisov[12], P. O. Hopcroft[5], D. P. Lettenmaier[8], W. J. Riley[14], J. S. Singarayer[5], Z. M. Subin[14], H. Tian[11], S. Zürcher[7], V. Brovkin[15], P. M. van Bodegom[16], T. Kleinen[15], Z. C. Yu[17], and J. O. Kaplan[1]





Freshwater Methane Emissions Offset the Continental Carbon Sink

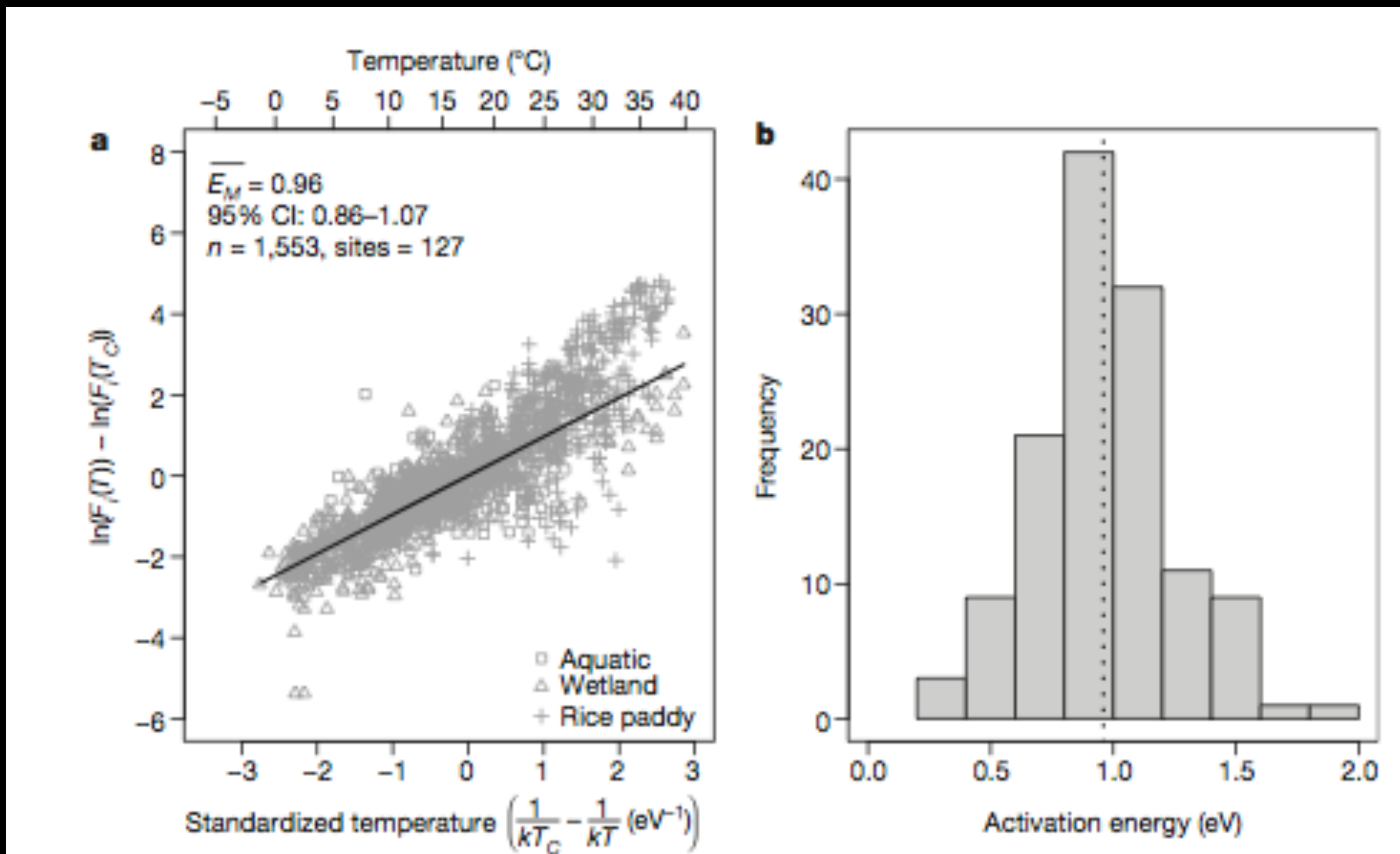
David Bastviken,[1]* Lars J. Tranvik,[2] John A. Downing,[3] Patrick M. Crill,[4] Alex Enrich-Prast[5]

LETTER

doi:10.1038/nature13164

Methane fluxes show consistent temperature dependence across microbial to ecosystem scales

Gabriel Yvon-Durocher[1], Andrew P. Allen[2], David Bastviken[3], Ralf Conrad[4], Cristian Gudasz[5,6]†, Annick St-Pierre[7], Nguyen Thanh-Duc[8] & Paul A. del Giorgio[7]

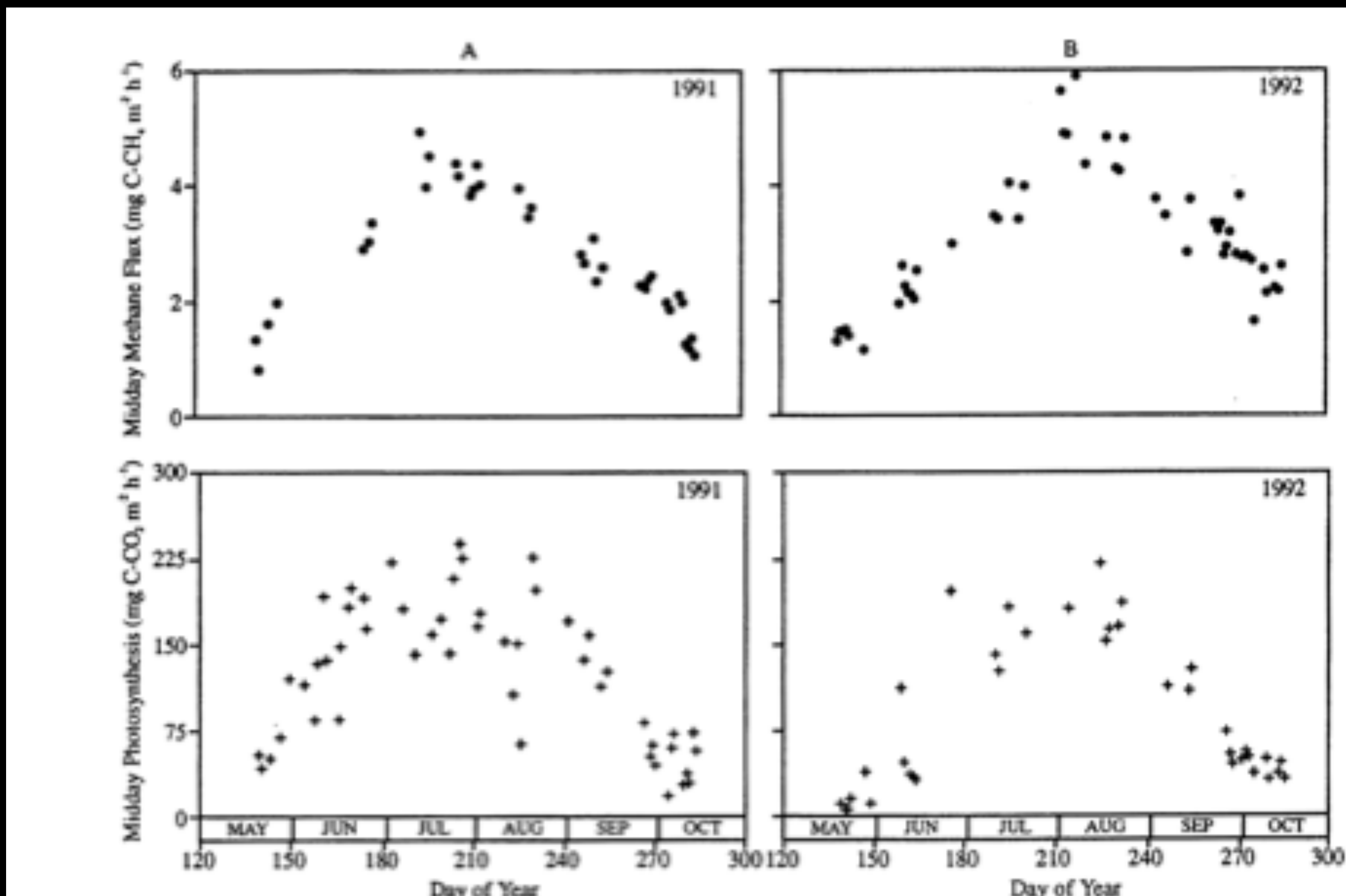


Biogeochemistry **40:** 1–15, 1998.

Micrometeorological measurements of methane flux in a Minnesota peatland during two growing seasons

N.J. SHURPALI[1,2] & S.B. VERMA[1,*]

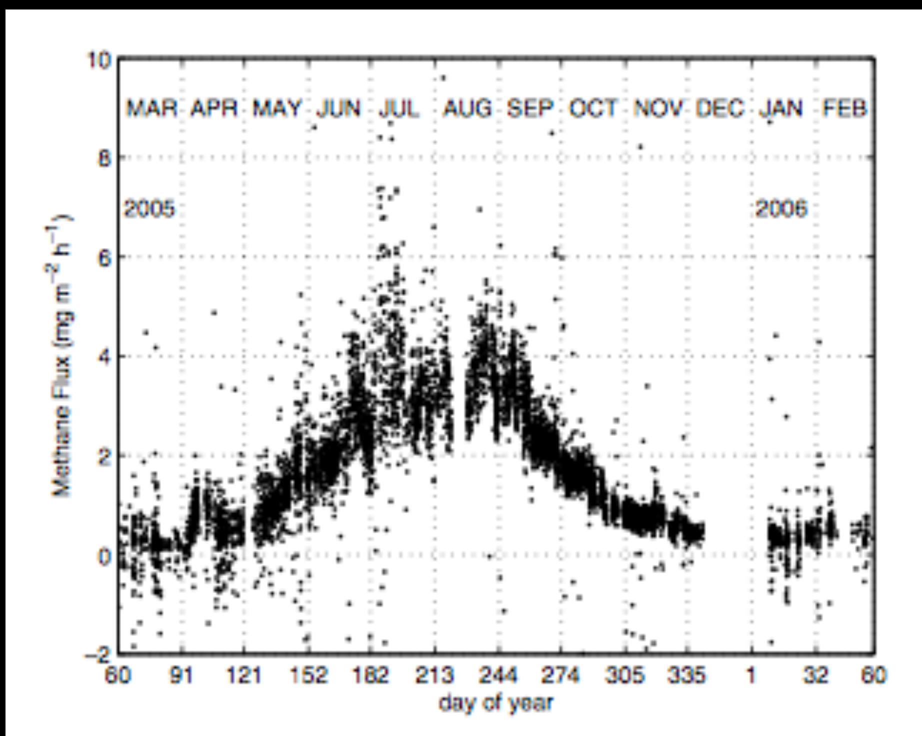
[redacted]

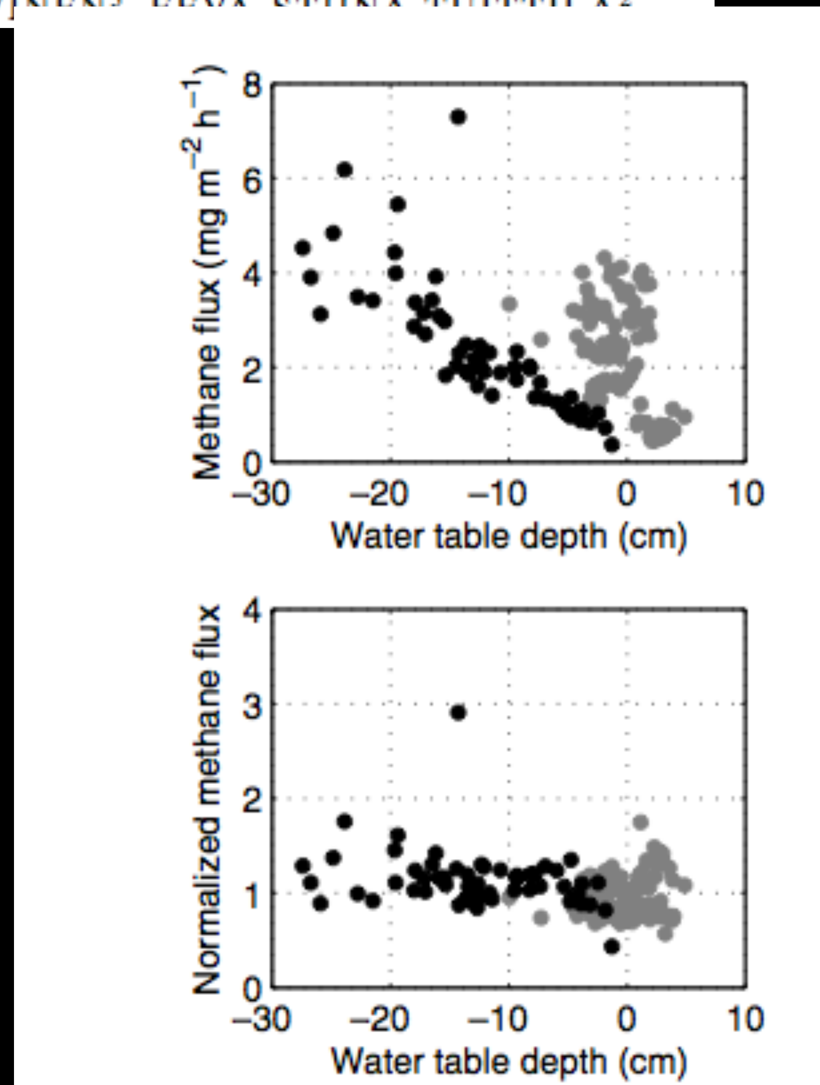


Annual cycle of methane emission from a boreal fen measured by the eddy covariance technique

2007

By JANNE RINNE[1*], TERHI RIUTTA[2], MARI PIHLATIE[1], MIKA AURELA[3],
SAMI HAAPANALA[1], JUHA-PEKKA TUOV

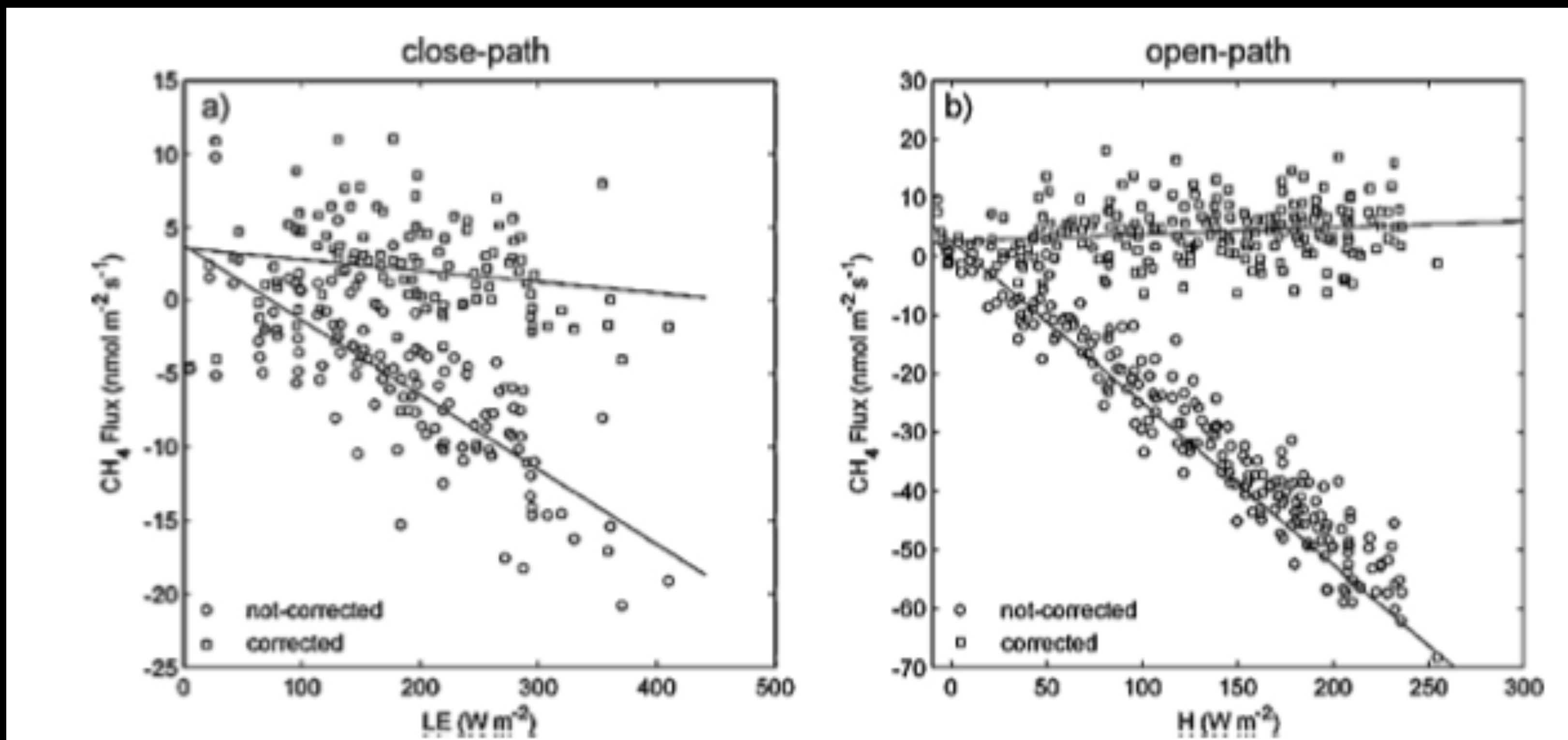




Comparing laser-based open- and closed-path gas analyzers to measure methane fluxes using the eddy covariance method

Matteo Detto[a,*], Joseph Verfaillie[a], Frank Anderson[b], Liukang Xu[c], Dennis Baldocchi[a]

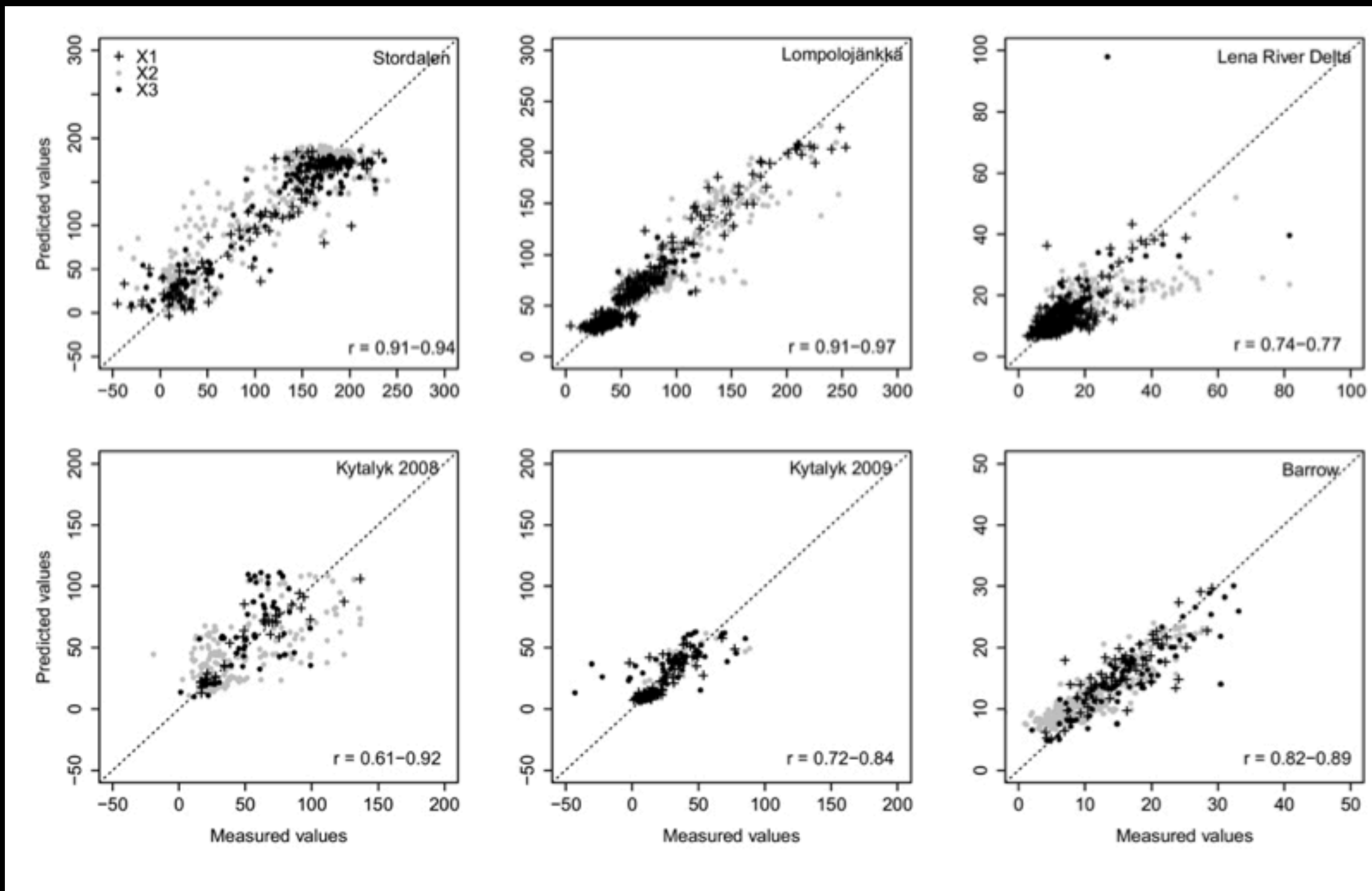
2011, AgForMet

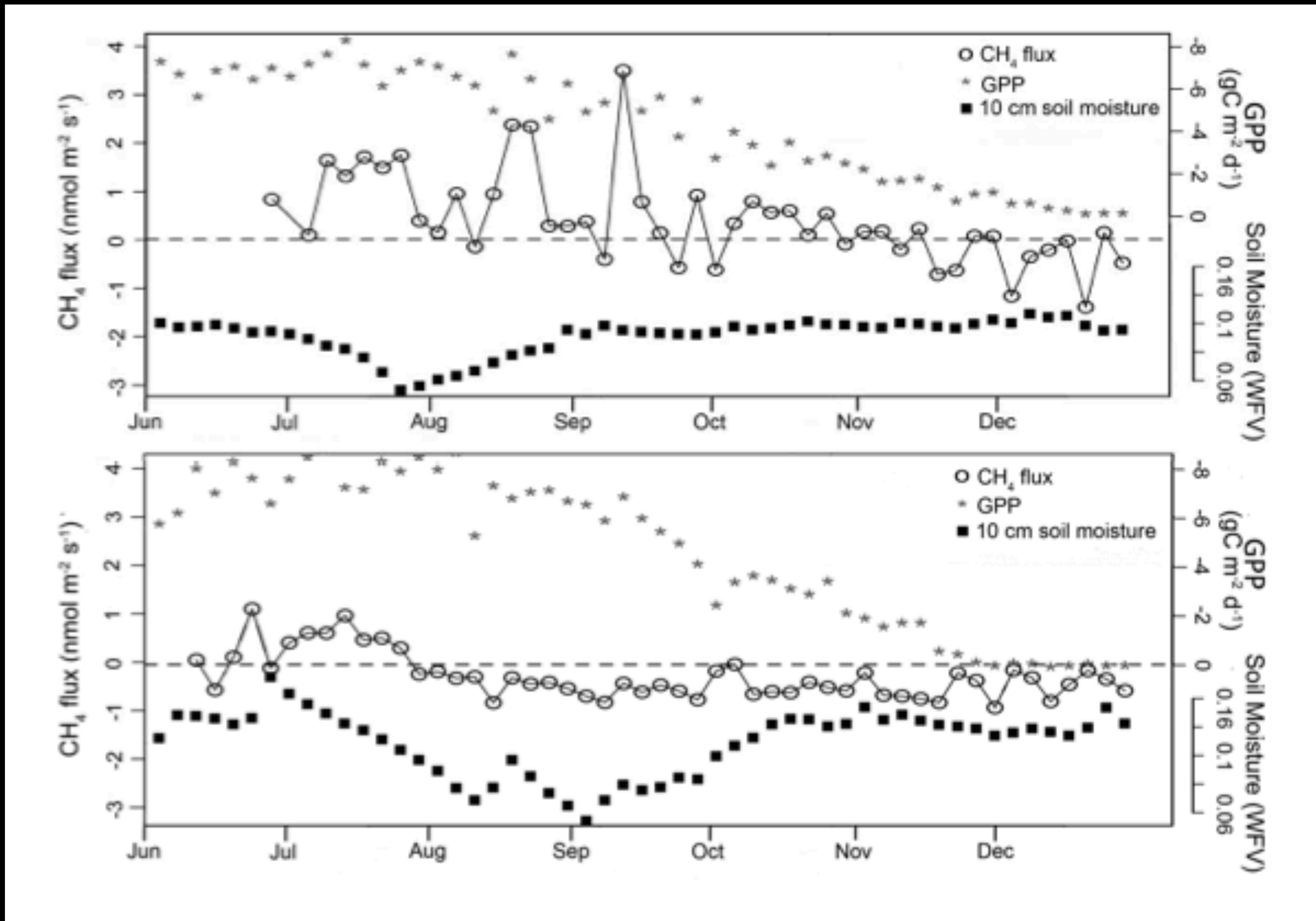


Testing the applicability of neural networks as a gap-filling method using CH_4 flux data from high latitude wetlands

Biogeosci, 2013

S. Dengel[1], D. Zona[2,3], T. Sachs[4], M. Aurela[5], M. Jammet[6], F. J. W. Parmentier[7], W. Oechel[3], and T. Vesala[1]



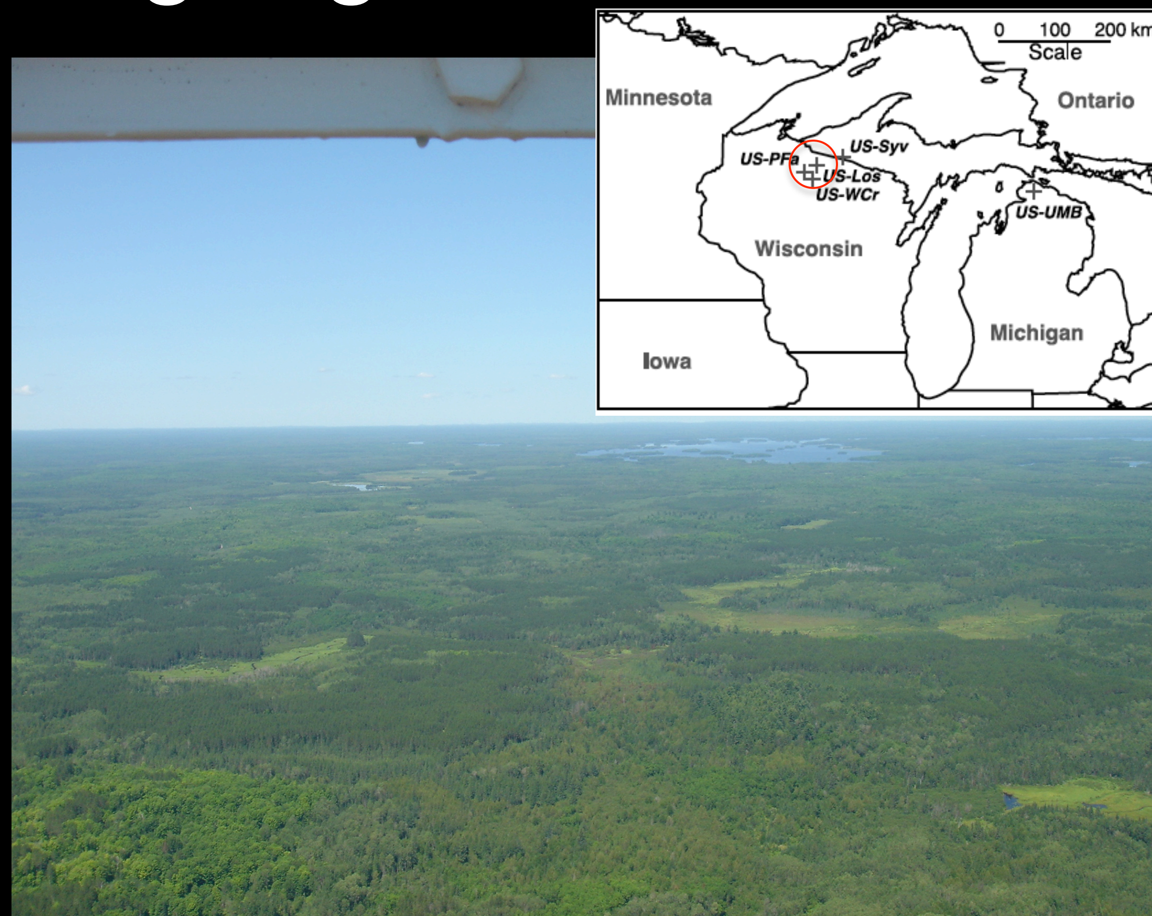


Shoemaker et al., 2013, GRL

So what do we get from a very tall CH_4 flux tower?

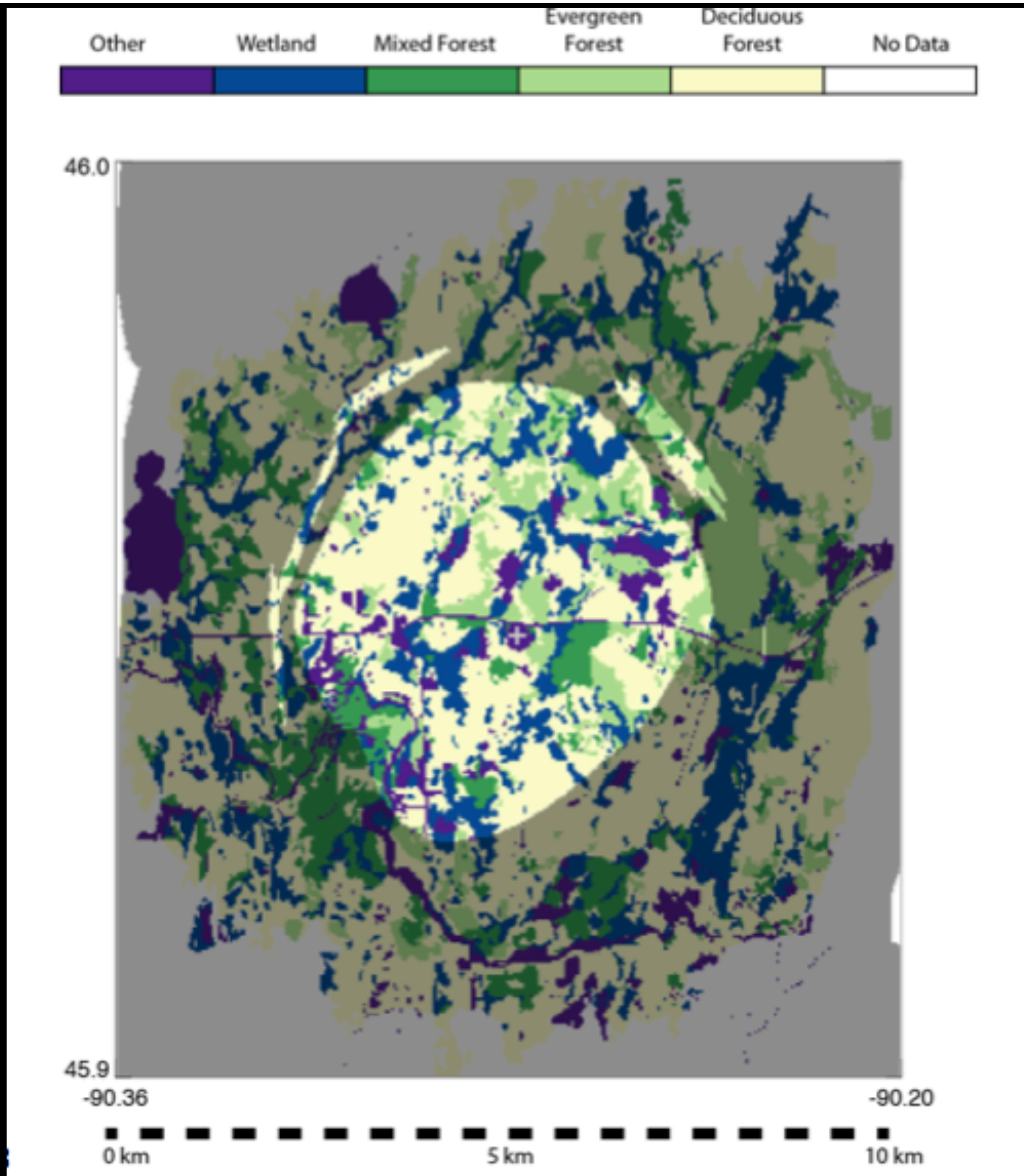
- Desai, A.R., Xu, K., Tian, H., Weishampel, P., Thom, J., Baumann, D., Andrews, A.E., Cook, B.D., King, J.Y., and Kolka, R., 2014. Landscape-level terrestrial methane flux observed from a very tall tower. Agric. Forest Meteorol., “submitted”.

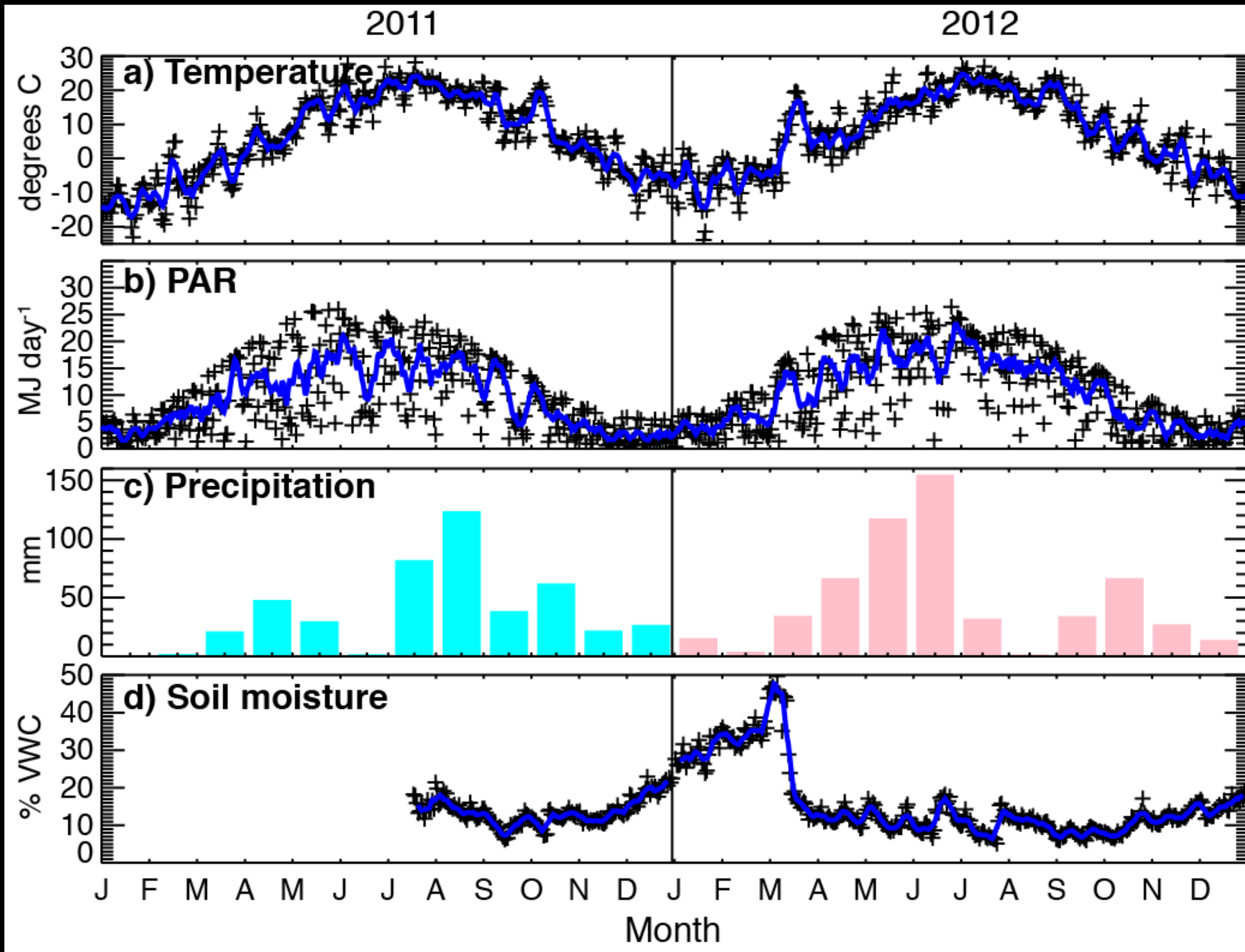
Tall towers offer novel approach to estimating regional fluxes



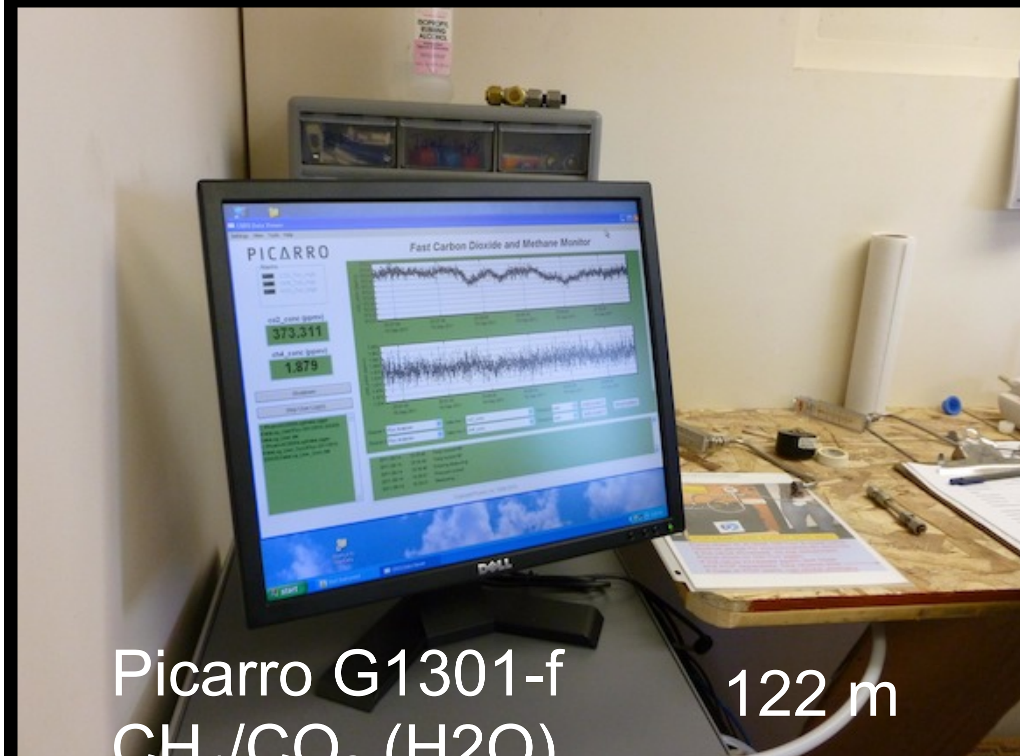
Credit: M. Rydzik

Source: B. Cook


Other
Wetland
Mixed Forest
Evergreen Forest
Deciduous Forest
No Data
46.0
45.9
-90.36
-90.20
0 km
5 km
10 km

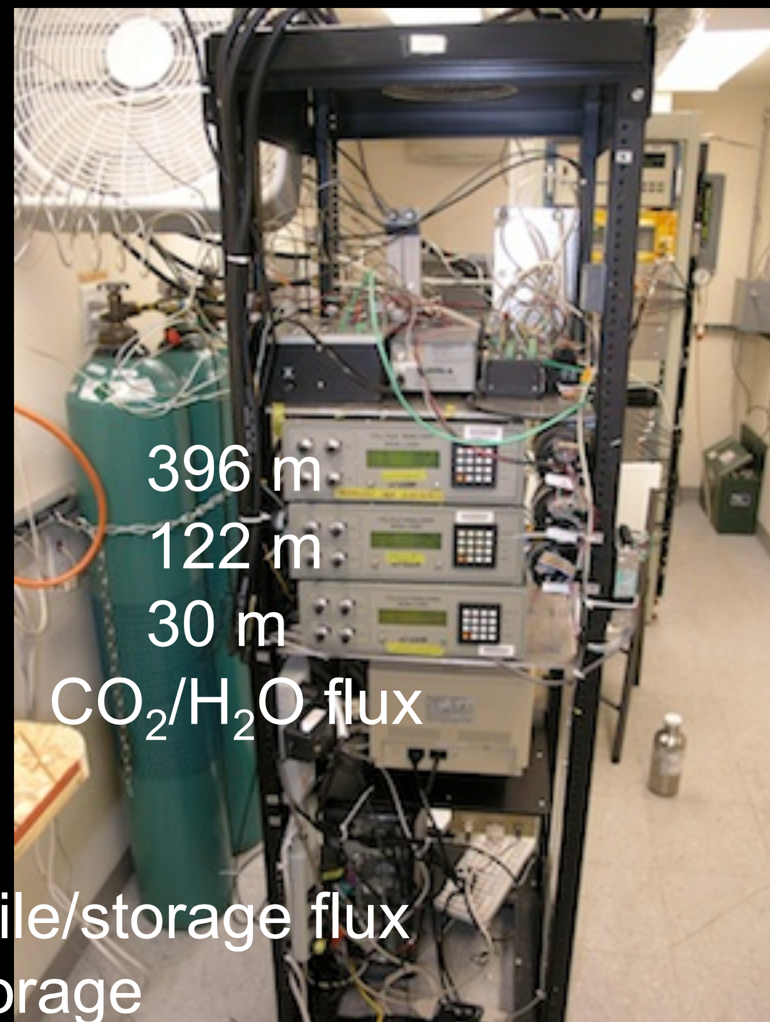

2011
2012
a) Temperature
degrees C
30
20
10
0
-10
-20
b) PAR
MJ day⁻¹
30
25
20
15
10
5
0
c) Precipitation
mm
150
100
50
0
d) Soil moisture
% VWC
50
40
30
20
10
0
J F M A M J J A S O N D J F M A M J J A S O N D
Month

Long-term continuous CH_4 eddy covariance is now feasible



Picarro G1301-f
CH_4/CO_2 (H2O)
122 m

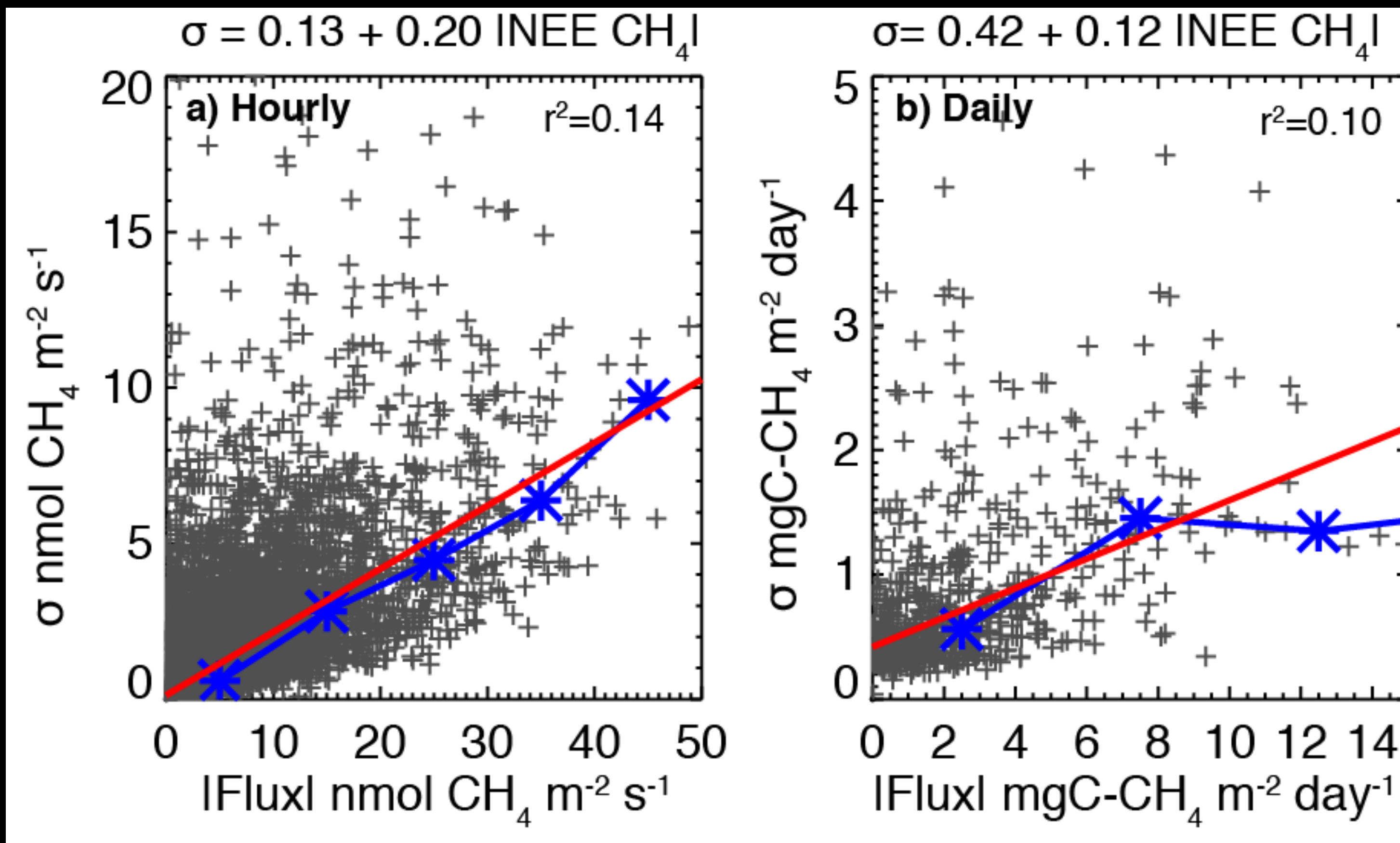
Credit: M. Rydzik



396 m
122 m
30 m
CO_2/H_2O flux

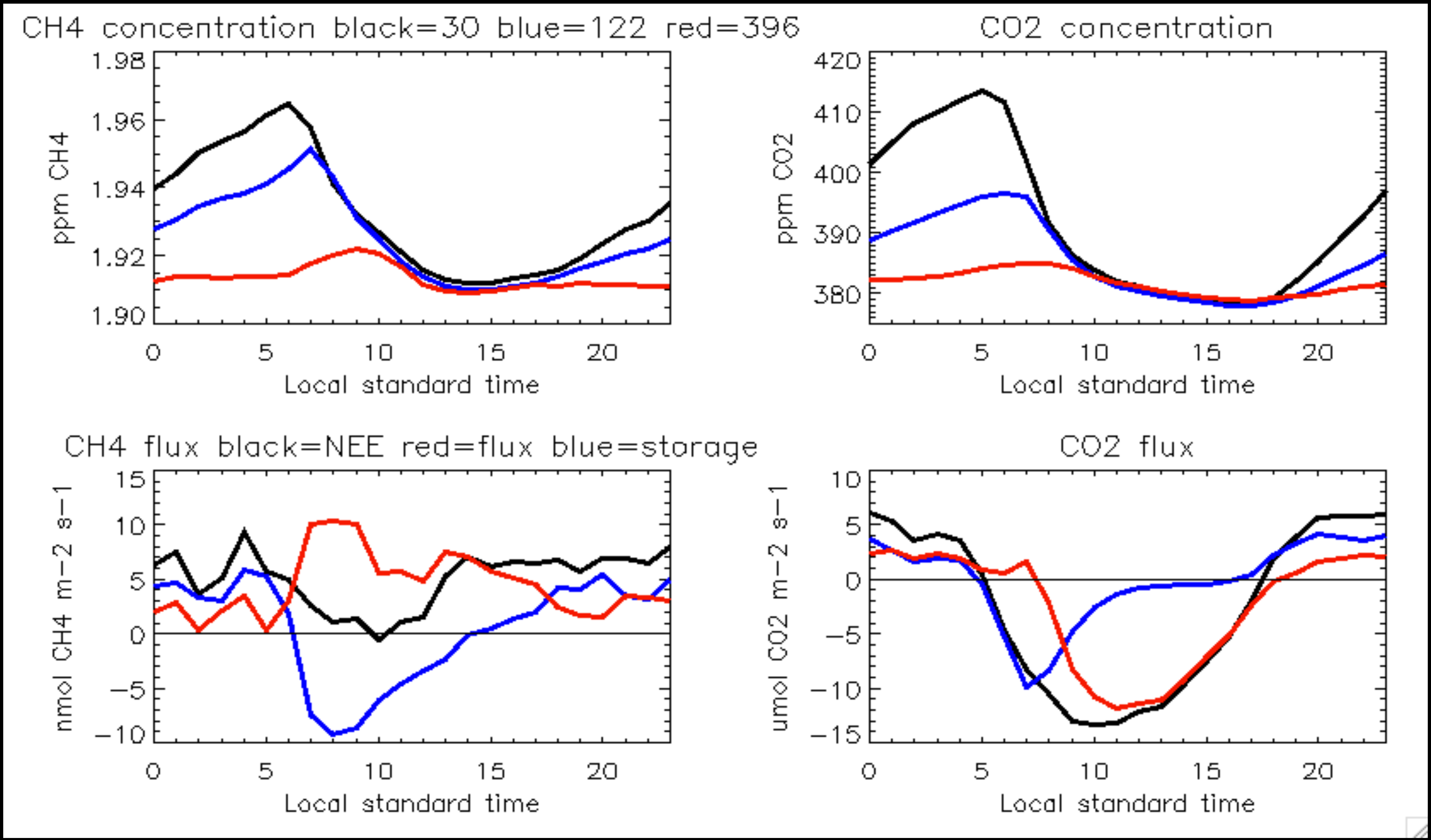
Not shown: Los Gatos for CH_4 profile/storage flux
LI-7000 (NOAA) for CO2 profile/storage

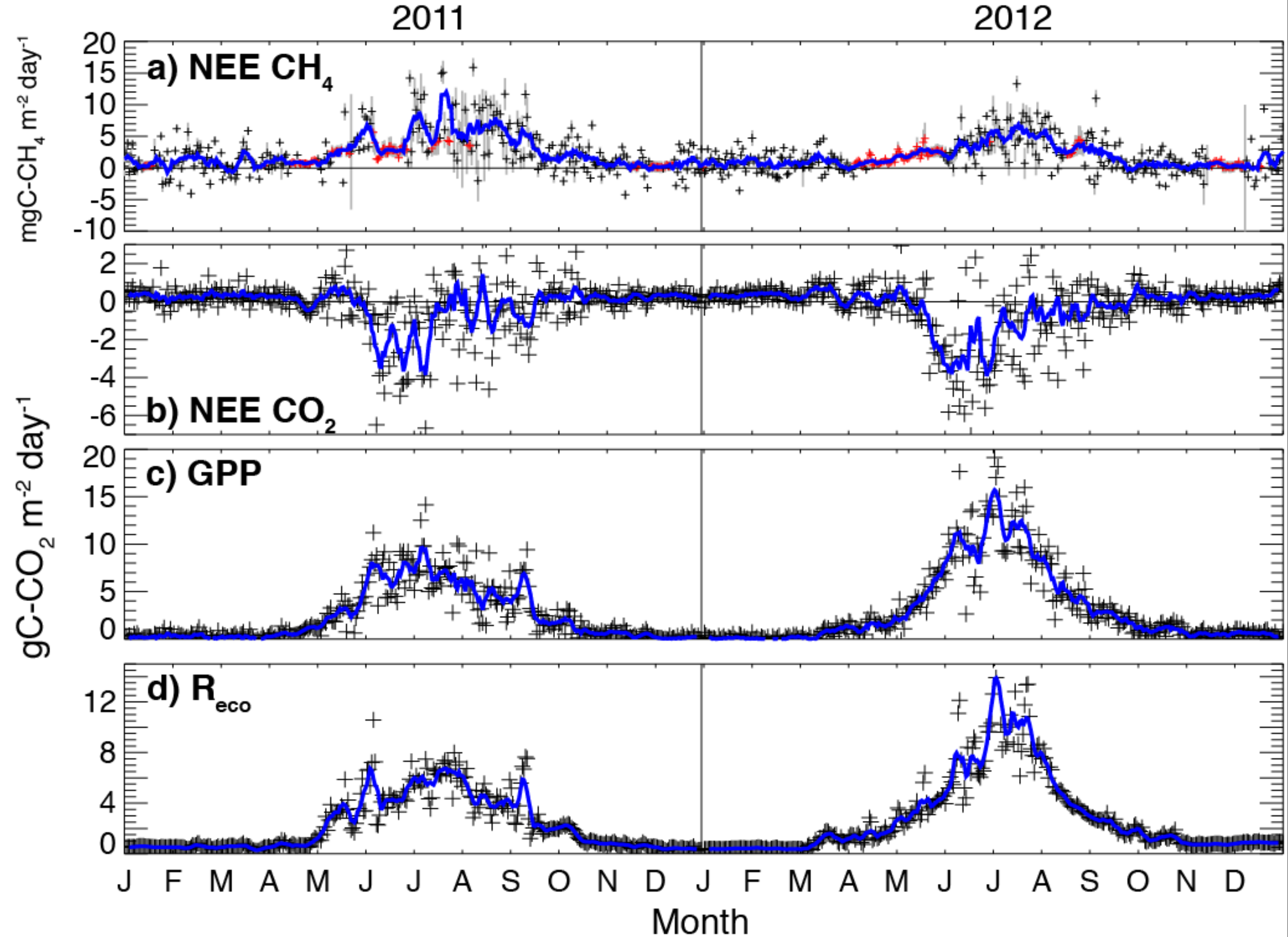
CH_4 random uncertainty can be large but a reasonable level of detection is possible



Based on approach of Salesky et al (2012) BLM

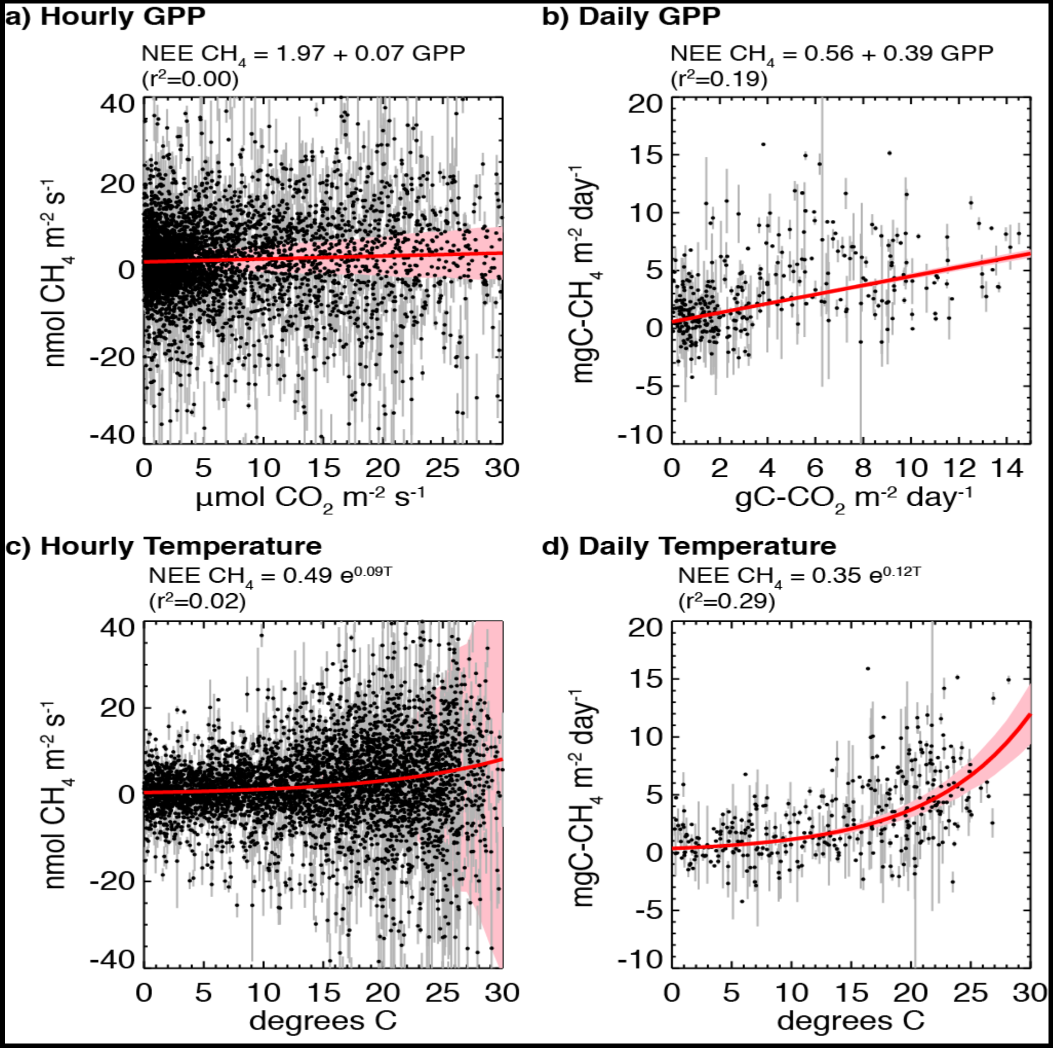
Storage flux is more complicated for CH_4 than CO_2 NEE



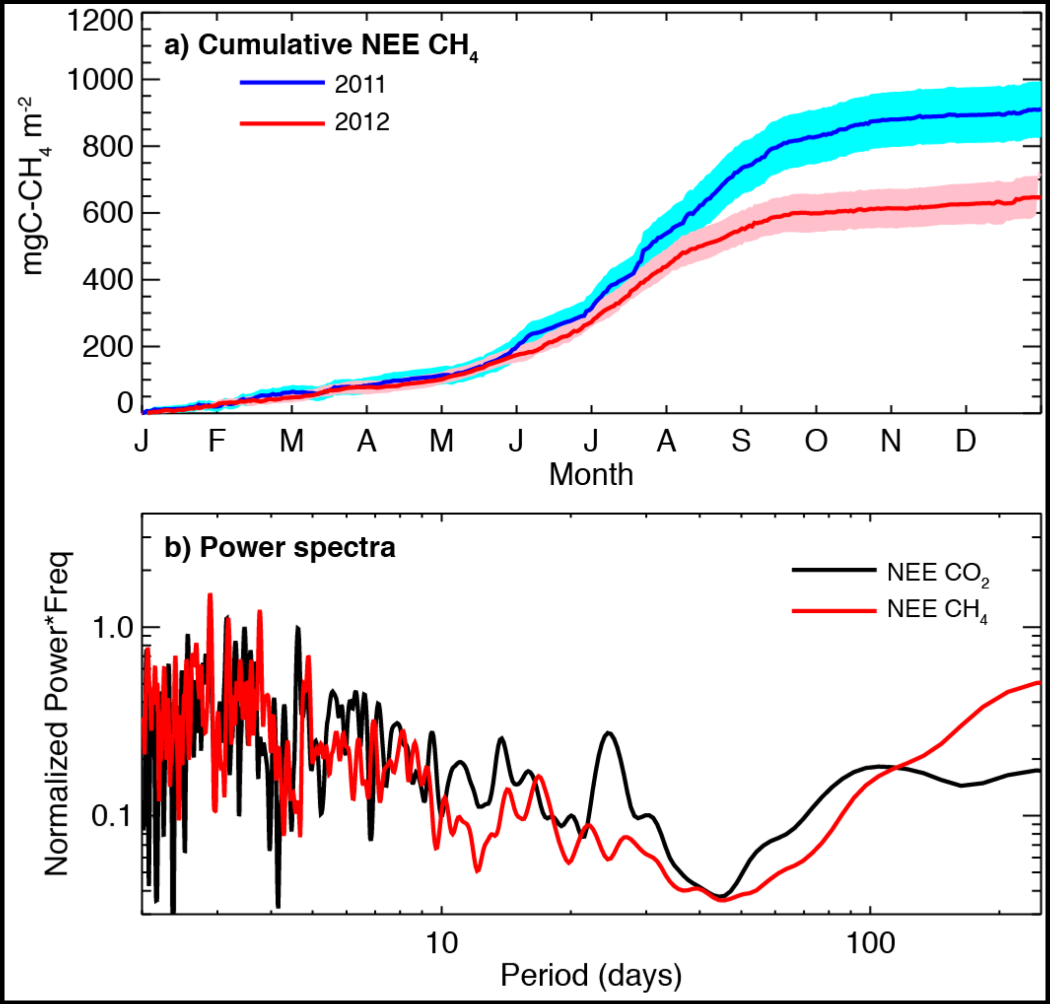


2011
2012
a) NEE CH4
b) NEE CO2
c) GPP
d) Reco
mgC-CH4 m-2 day-1
gC-CO2 m-2 day-1
J F M A M J J A S O N D J F M A M J J A S O N D
Month

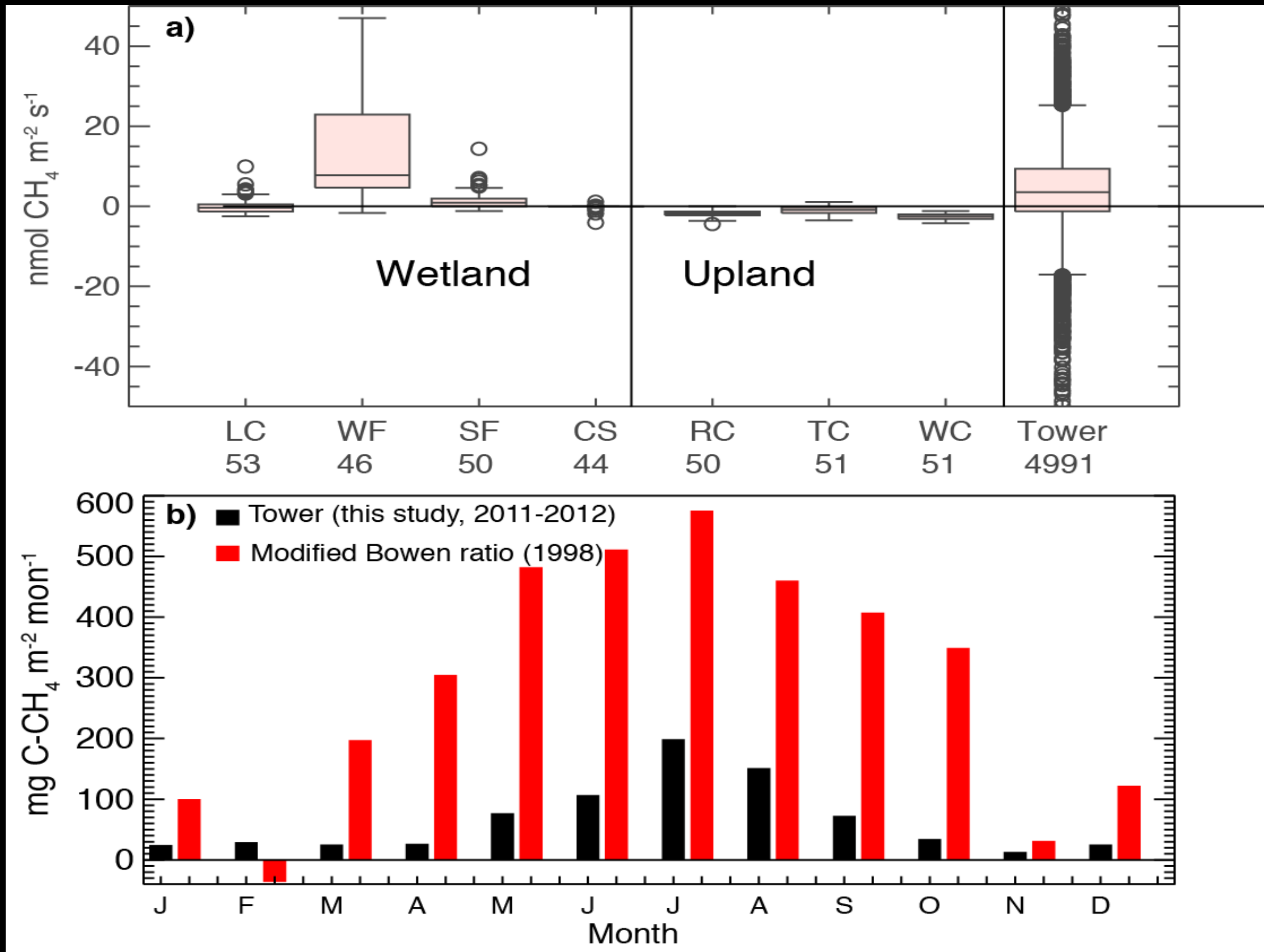
Driving factors are trickier for CH_4! Temperature at daily scale…



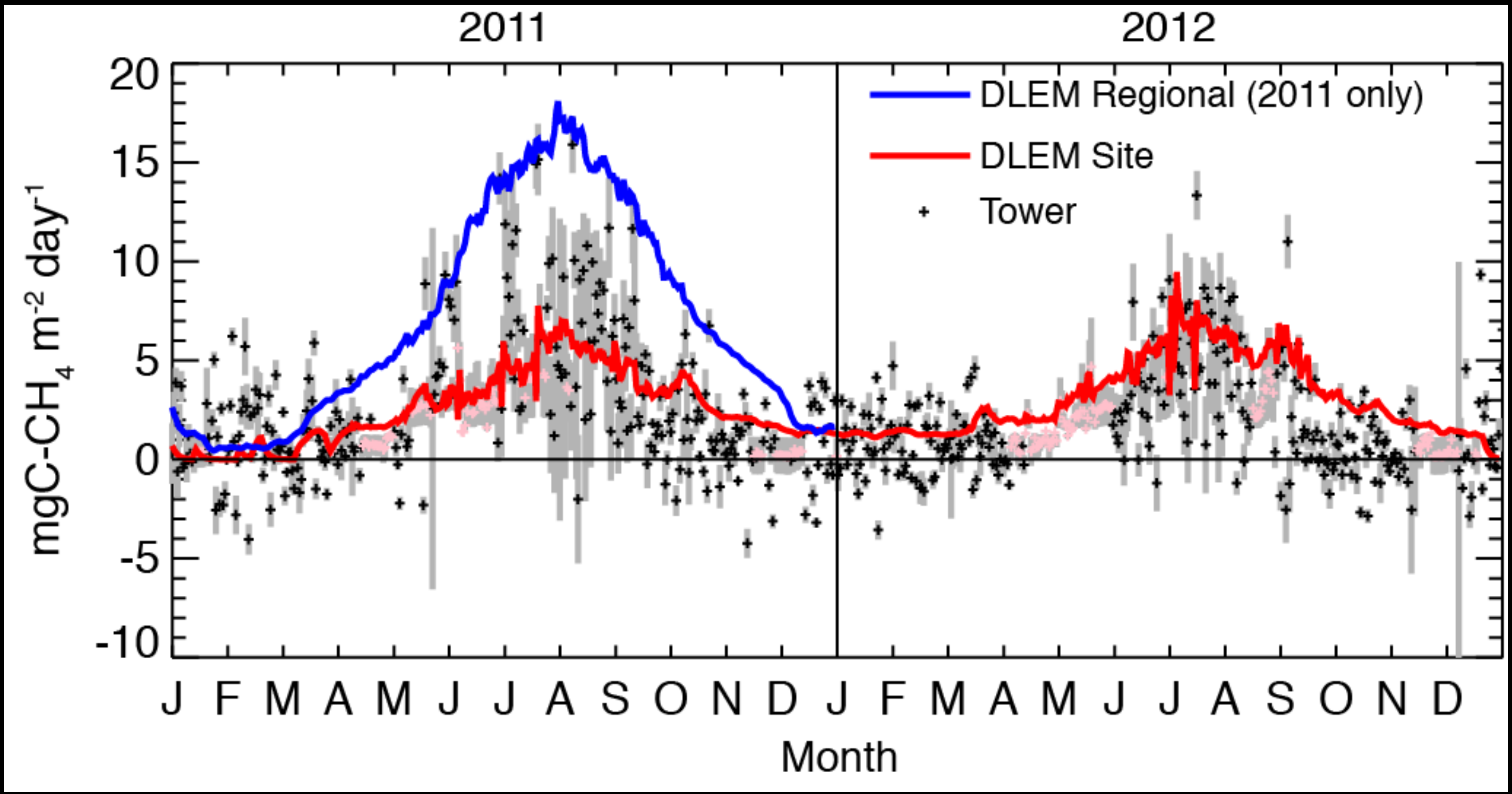
Moisture at annual scale



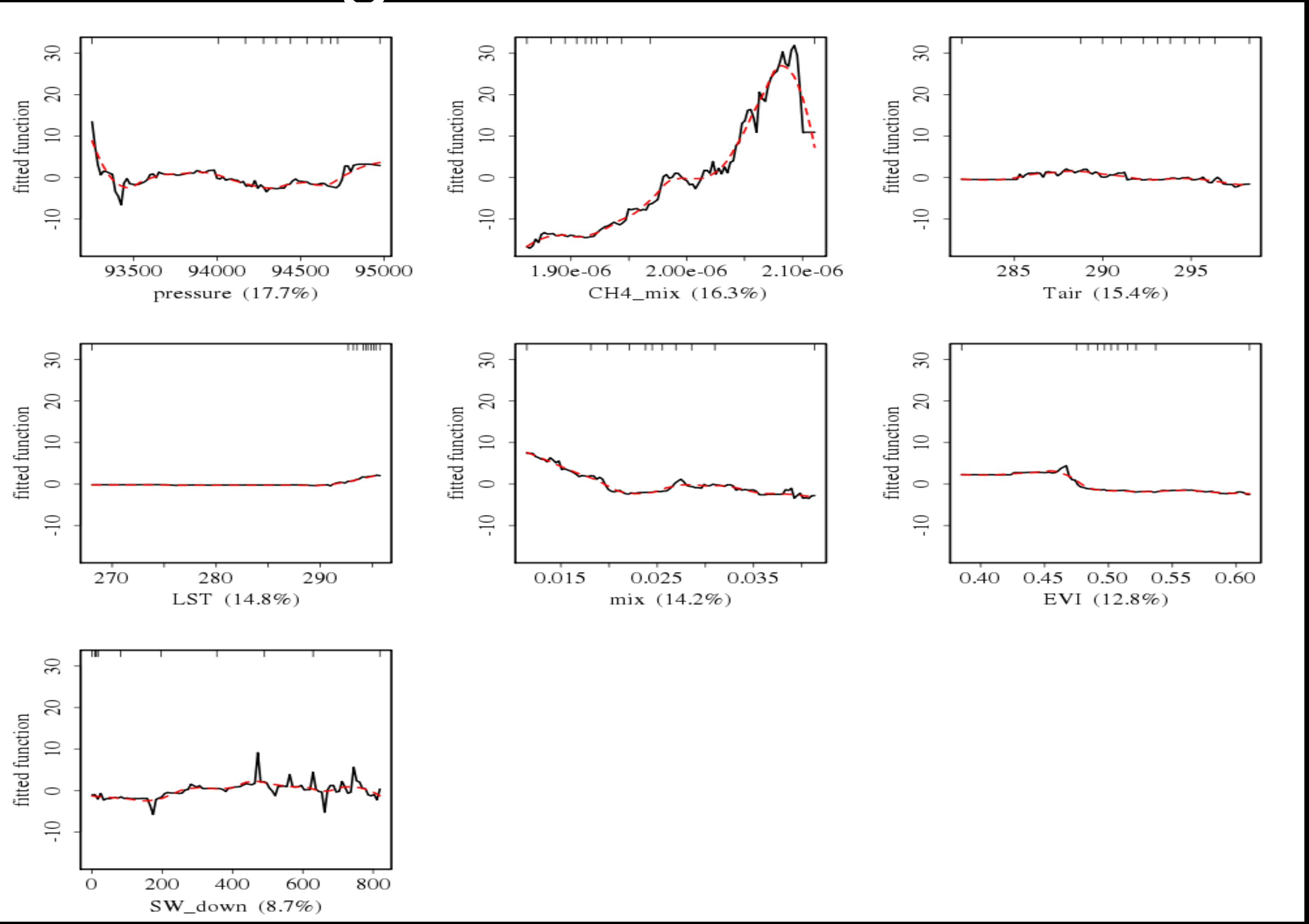
Chamber CH4 fluxes show high inter and intra site variability, and scaled fluxes are ~1/3 of tower, while tower is less than a profile similarity approach



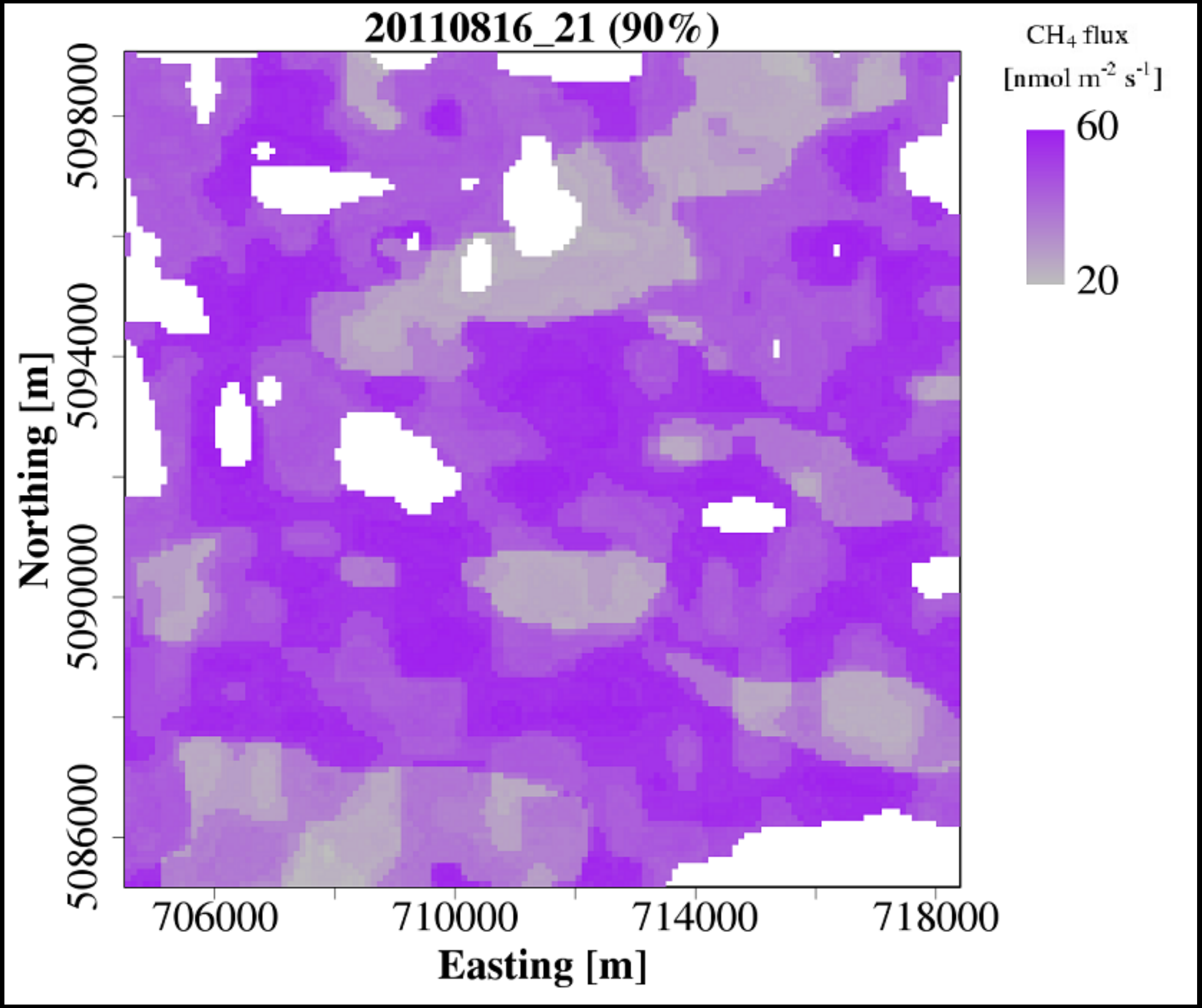
Models get seasonal pattern but not interannual variability or large emissions



ERF model shows pressure and mixing ratio drivers of flux



Gridded ERF functions show significant spatial variability in CH_4 flux



What does tower synthesis say so far?

- Petrescu, A.M., Lohila, A., Baldocchi, D.D., Desai, A.R., Tuovinen, J.P., Vesala, T., et al., 2014. The controversial climate footprint of wetlands under human pressure: carbon sink or methane source? Nature, #2013-07-09156A-Z, in review.

SLIDES REMOVED PENDING PUBLICATION

So is methane interesting?

- NO: short-lifetime, small flux in most forests, only ecologically relevant for wetlands/agriculture/tropics and arctic, anthropogenic source more important, hard/expensive to measure flux well,
- YES: high short-term (policy-relevant) radiative forcing, ecosystem climate sensitivities involve CH_4 and CO_2 flux tradeoffs, tracer of microbial ecology, data and models show lots of uncertainty and invalidity of prior assumptions of fixed ratios, …

- What do *you* think?

Thank you!

- NSF CAREER DEB #0845166
- DOE Ameriflux Network Management Program
- NEON Service Agreement to U Wisconsin
- WLEF/ Park Falls (US-PFa) tall tower research partners: NOAA ESRL (A. Andrews, J. Kofler), USFS NRS (M. Kubiske, D. Baumann), Penn State (K. Davis), Cal Tech (P. Wennberg), COSMOS (M. Zreda), NASA GSFC (B. Cook), WI ECB (J. Ayers) , Ameriflux, NEON (S. Metzger)
- Desai lab at UW:J Thom, K Xu, and others
  - http://flux.aos.wisc.edu
  - desai@aos.wisc.edu
  - 608-218-4208