Is Methane Interesting?

Ankur R Desai
University of Wisconsin

http://purefixion.com/attention/2006/03/cow-farts.html
Methane
1.8 ppm
Atmos lifetime ~10 yrs

Carbon Dioxide
400 ppm
30-100+ years
Mauna Loa, Hawaii, United States (MLO)

Source: NOAA ESRL
Methane SCIAMACHY/ENVISAT 2003-2005

http://www.iup.uni-bremen.de/sciamachy/
NIR_NADIR_WFM_DOAS/wfmd_image_gallery_ch4.html
Global Anthropogenic CH₄ Budget by Source in 2000

- Natural gas: 15%
- Solid waste: 13%
- Waste water: 10%
- Fuel stat. & mobile: 8%
- Coal: 8%
- Oil: 1%
- Biomass burning: 5%
- Biofuel combustion: 4%
- Enteric fermentation: 28%
- Manure: 4%
- Rice: 11%

Total CH₄ emissions in 2000 = 262.6 Tg CH₄

Source: Picarro, Inc. / Nathan Phillips, BU
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
Freshwater Methane Emissions Offset the Continental Carbon Sink

David Bastviken, Lars J. Tranvik, John A. Downing, Patrick M. Crill, Alex Enrich-Prast
Methane fluxes show consistent temperature dependence across microbial to ecosystem scales

Gabriel Yvon-Durocher¹, Andrew P. Allen², David Bastviken³, Ralf Conrad⁴, Cristian Gudasz⁵,⁶, Annick St–Pierre⁷, Nguyen Thanh–Duc⁸ & Paul A. del Giorgio⁹
Micrometeorological measurements of methane flux in a Minnesota peatland during two growing seasons

N.J. SHURPILI\textsuperscript{1,2} & S.B. VERMA\textsuperscript{1,*}
Annual cycle of methane emission from a boreal fen measured by the eddy covariance technique

By JANNE RINNE\textsuperscript{1*}, TERHI RIUTTA\textsuperscript{2}, MARI PIHLATIE\textsuperscript{1}, MIKA AURELA\textsuperscript{3}, SAMI HAAPANALA\textsuperscript{1}, JUHA-PEKKA TUOMISALO\textsuperscript{1}, TERO STUMA-TIITTULA\textsuperscript{2}

2007
Comparing laser-based open- and closed-path gas analyzers to measure methane fluxes using the eddy covariance method

Matteo Detto\textsuperscript{a,*}, Joseph Verfaillie\textsuperscript{a}, Frank Anderson\textsuperscript{b}, Liukang Xu\textsuperscript{c}, Dennis Baldocchi\textsuperscript{a}

2011, AgForMet
Testing the applicability of neural networks as a gap-filling method using CH$_4$ flux data from high latitude wetlands

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$^1$
So what do we get from a very tall CH$_4$ flux tower?

Tall towers offer novel approach to estimating regional fluxes

Credit: M. Rydzik  
Source: B. Cook
Long-term continuous CH$_4$ eddy covariance is now feasible

Picarro G1301-f
CH$_4$/CO$_2$ (H2O)

Credit: M. Rydzik

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

a) NEE CH₄

b) NEE CO₂

c) GPP

d) R_{eco}

Month
Driving factors are trickier for CH₄! Temperature at daily scale...

- **Hourly GPP**
  - NEE CH₄ = 1.97 + 0.07 GPP
  - \( r^2 = 0.00 \)

- **Daily GPP**
  - NEE CH₄ = 0.56 + 0.39 GPP
  - \( r^2 = 0.19 \)

- **Hourly Temperature**
  - NEE CH₄ = 0.49 e^{0.09T}
  - \( r^2 = 0.02 \)

- **Daily Temperature**
  - NEE CH₄ = 0.35 e^{0.12T}
  - \( r^2 = 0.29 \)
Moisture at annual scale

Graphs showing cumulative NEE CH₄ over months and power spectra over different periods.
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?

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