Measurements of Methane Flux Using a Fast Open-Path Analyzer

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Introduction

Methane is an important greenhouse gas that has a warming potential about 23 times that of CO_2 over 100-year cycle (Houghton *et al.*, 2001).

Measurements of CH_4 fluxes from the terrestrial biosphere have mostly been made using flux chambers, which are discrete in time and space, and may disturb surface integrity and air pressure.

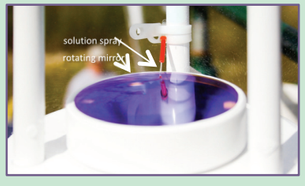
Open-path analyzers offer a number of advantages for measuring CH_4:

- undisturbed *in-situ* flux measurements
- spatial integration using the Eddy Covariance approach
- zero frequency response errors due to tube attenuation
- confident water and thermal density terms from co-located standard fast measurements of water and sonic temperature
- remote deployment due to lower power demand without a pump

Instrument description

The prototype open-path methane analyzer (left) is a VCSEL laser-based instrument employing an open Herriott cell design

Field maintenance is minimized by a self-cleaning mechanism (bottom) to keep the lower mirror free of contamination



Sites and Experiments

Eddy Covariance measurements of CH_4 flux using the prototype methane analyzer were conducted in 2006-2008 at three ecosystems with contrasting weather and moisture conditions:

- Fluxes over short-hydroperiod sawgrass wetland in Florida Everglades were measured in warm and humid conditions with temperatures often exceeding 25°C, with variable winds, and heavy dew at night
- Experiment in an Arctic tundra described fluxes over coastal wetlands with frequent sub-zero temperatures, mist, and moderate winds
- Fluxes over pacific mangroves in Mexico were measured in conditions of high winds, sea spray, and moderate air temperatures

Eddy covariance flux data from a co-located prototype methane analyzer, LI-7500 and sonic anemometer were collected at a 10 Hz rate. Data were processed using EdiRe software following standard FluxNet methodology (Aubinet *et al.,* 2000).

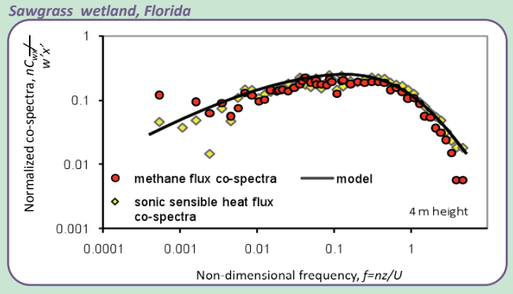
CH_4 flux co-spectra

Ensemble averages of normalized daytime co-spectra plotted versus non-dimensional frequency are shown for contrasting ecosystems and setups in the three figures below.

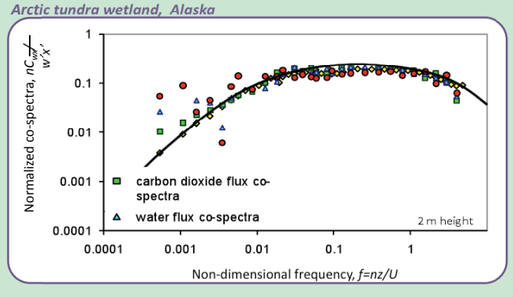
In all cases methane co-spectra behaved in a manner similar to the co-spectra of CO_2, H_2O, and air temperature, demonstrating that the prototype open-path methane analyzer adequately measured fluctuations in CH_4 concentration across the whole spectrum of frequencies that contributed to turbulent transport.

All the co-spectra also closely followed the Kaimal model (Kaimal *et al.*, 1972), and demonstrated good agreement with another methane co-spectrum obtained with a TDLS (Unisearch Associates, Inc.) over peatland (Verma *et. al.*, 1992).

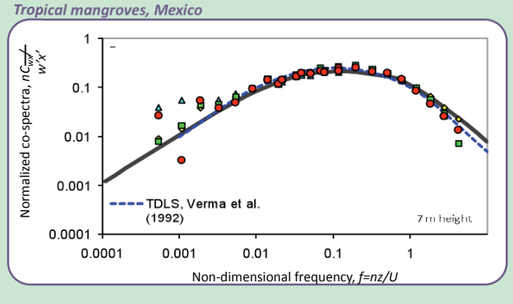
Sawgrass wetland, Florida



Arctic tundra wetland, Alaska



Tropical mangroves, Mexico



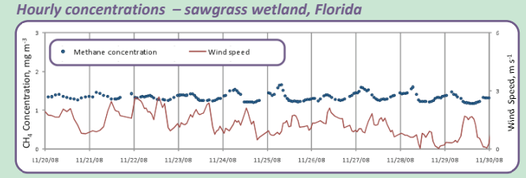
CH_4 concentrations and fluxes

Examples of hourly CH_4 concentrations and fluxes are shown in the top three figures below. The fourth figure demonstrates longer-term CH_4 emissions integrated over daytime from November, 2007, through January, 2008, in sawgrass wetland, alongside mean air temperature.

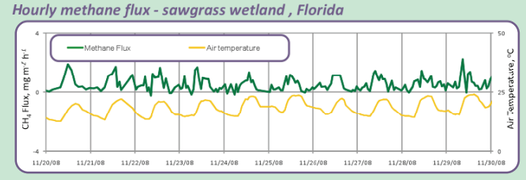
Overall, hourly CH_4 fluxes ranged from near-zero at night to 4 mg m^{-2} h^{-1} in arctic tundra (Zona *et al.*, 2008) and pacific mangroves (not shown), and to 2.5 mg m^{-2} h^{-1} in sawgrass wetland.

Observed fluxes were within the ranges reported in the literature for a number of wetlands in North America, including the Everglades wetlands in Florida (Harriss *et al.*, 1988), fen in Canada (Bubier *et al.*, 1993), peatland in Minnesota (Shurpali and Verma, 1998) and bog in Alaska (Moosavi *et al.*, 1996).

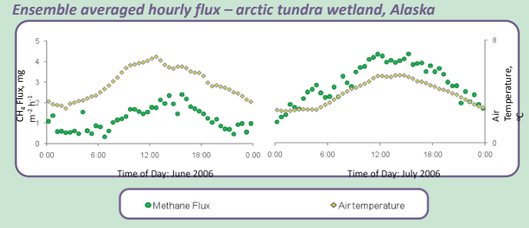
Hourly concentrations – sawgrass wetland, Florida



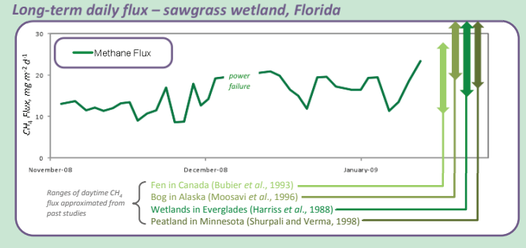
Hourly methane flux - sawgrass wetland , Florida



Ensemble averaged hourly flux – arctic tundra wetland, Alaska



Long-term daily flux – sawgrass wetland, Florida

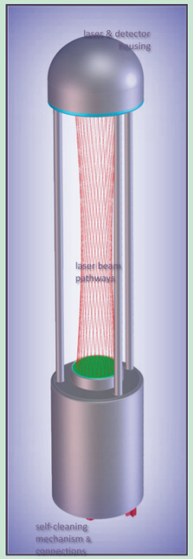


Summary and Conclusions

- Open-path measurements of CH_4 flux using Eddy Covariance approach were conducted in 3 contrasting ecosystems:

  sawgrass wetland
  wetlands of arctic tundra
  tropical pacific mangroves

- In all 3 experiments, the shape of CH_4 flux co-spectra was close to those of CO_2, H_2O, and sensible heat fluxes
- CH_4 concentration ranged 1.1-1.6 mg m^{-3}, with hourly variations close to those observed in similar ecosystems
- Hourly fluxes ranged from near-zero at night to about 4 mg m^{-2} h^{-1} at midday in the arctic tundra
- Diurnal patterns were similar to those measured by closed-path sensors (Kim *et al.*, 1998; Hendriks *et al.*; *etc.)*
- Open-path analyzer is a valuable tool for measuring long-term eddy fluxes of CH_4 due to its good frequency response and undisturbed *in-situ* sampling



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