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 CO₂ over 100-year cycle (Houghton et al., 2001). Measurements of CH₄ 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 CH₄:

- 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

CH₄ flux co-spectra

Ensemble averaged 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 CO₂, H₂O, and air temperature, demonstrating that the prototype open-path methane analyzer adequately measured fluctuations in CH₄ concentration across the whole spectrum of frequencies that contributed to turbulent transport. All the co-spectra also closely followed the Karjal model (Karjal et al., 1972), and demonstrated good agreement with another methane co-spectrum obtained with a TDL (Unisearch Associates, Inc.) over peatland (Verma et al., 1992).

CH₄ concentrations and fluxes

Examples of hourly CH₄ concentrations and fluxes are shown in the top three figures below. The fourth figure demonstrates longer-term CH₄ emissions integrated over daytime from November, 2007, through January, 2008, in a sawgrass wetland, alongside mean air temperature. Overall, hourly CH₄ fluxes ranged from near-zero at night to about 4 mg m⁻² h⁻¹ in an arctic tundra (Zona et al., 2008) and Pacific mangroves (not shown), and to 2.5 mg m⁻² h⁻¹ in a sawgrass wetland.

Summary and Conclusions

- Open-path measurements of CH₄ flux using Eddy Covariance approach were conducted in 3 contrasting ecosystems:
  - sawgrass wetland, central Florida
  - arctic tundra
  - Pacifc mangroves

- In all 3 experiments, the shape of CH₄ flux co-spectra was close to those of CO₂, H₂O, and spectral heat fluxes.

- CH₄ 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 midnight in the arctic tundra.

- Diurnal patterns were similar to those measured by closed-path sensors (Kim et al., 1998; Hendriks et al., 1999).

- Open-path analyzer is a valuable tool for measuring long-term eddy fluxes of CH₄ due to its good frequency response and undisturbed in-situ sampling.

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Instrument description

The prototype open-path methane analyzer (OPA) is a VCSEL laser-based instrument employing an open flow 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 CH₄ 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 27°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.

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