Methane emissions from the Arctic Coastal Plain in Alaska

Zona D.[1], W. Oechel[1], G. Burba[2], H. Ikawa[1], and C. Sturtevant[1]

[1] San Diego State University, San Diego, CA, USA; [2] LI-COR Biosciences, Lincoln, NE, USA

Introduction

Methane is an effective greenhouse gas that has a warming potential about 23 times more than carbon dioxide, for 100-year cycle. The wetland regions of the world, especially the ones in the boreal and low Arctic, are major accumulation sites of organic materials under anaerobic conditions, and could be a significant source of global methane under a warming climate. The large majority of measurements of methane emission from the terrestrial biosphere have been made using flux chambers. Such measurements result in discrete samples in time and space, and can cause a significant disturbance to surface integrity and transient soil-atmosphere pressure.

Materials and Methods

In our experiment (Figure 1) we utilized a new device, the LI-COR open-path methane test-bed instrument (TBI; LI-COR Biosciences, Lincoln, Nebraska) for eddy covariance flux measurements, and a closed-path TBI for gradient measurements. These new instruments provided continuous measurements over the growing season, were non-invasive, and allowed more accurate estimation of methane fluxes during the entire summer 2006. The continuous measurement for three months period is particularly important because most of the past Arctic measurements were conducted during short periods in June or July (the peak growing season in the Alaskan arctic tundra) assuming that higher soil temperatures of summer would result in elevated methane emissions.

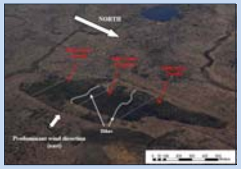

Figure 1. Aerial image of the site of Biocomplexity manipulation experiment in the Barrow Environmental Observatory (BEO) near Barrow, Alaska. Indicated in the figure are the orientation of the main axis of the vegetated drained lake (north-south) and the dominant wind direction (from the east). Two dikes (highlighted in gray) separate the three sites and prevent water from draining through the drainage channel in the southern part of the basin. Boardwalks run along and across the basin and provide access to the site avoiding soil and plant disturbance.

Eddy covariance flux data were collected at 10 Hz rate. Eddy flux data were processed using EdiRe software (Robert Clement, University of Edinburgh) generally following standard FluxNet methodology (Aubinet *et al.,* 2000), particularly including stationarity tests, and frequency and density corrections.

To assess the integrity of measured CH_4 fluxes for the entire duration of the test, TBI frequency response was examined. Ensemble averages of daytime co-spectra are shown for contrasting ecosystems and setups in Figures 2A and B: over arctic tundra in this study, and over tropical mangroves. In both cases methane co-spectra behaved in a manner similar to that of CO_2, H_2O, and sonic temperature, demonstrating that the TBI 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, and demonstrated a good agreement with another methane co-spectrum obtained with a TDLS (Unisearch Associates, Inc.) over peatland (Verma *et. al.*, 1992).

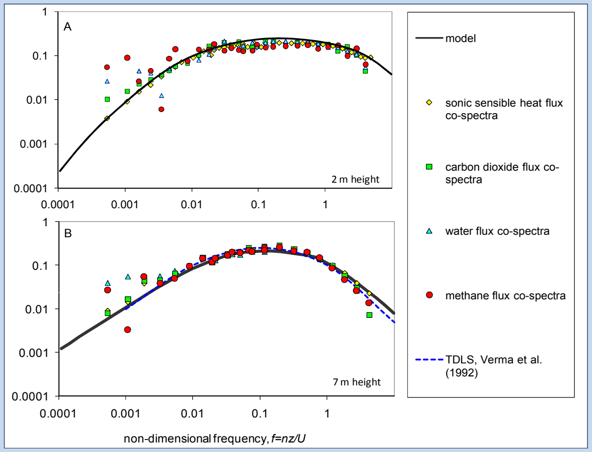

Figure 2. Ensemble average daytime normalized co-spectra ($nC_{wx}/\overline{w'x'}$) of sensible heat transfer ($w'T'$; Gill Solent Anemometer), carbon dioxide ($w'CO_2'$; LI-7500), water ($w'H_2O'$; LI-7500), and methane ($w'CH_4'$; LI-COR TBI): (A) over arctic tundra, and (B) over tropical mangroves. The Kaimal model (*model*) is plotted for comparison. Also shown is the CH_4 co-spectrum from a custom-built TDLS (Unisearch Associates, Inc.) over a peatland (Verma *et. al.*, 1992).

Results and Discussion

Figure 3 shows the average methane fluxes for June and July 2006 alongside the number of key environmental variables (*e.g.,* soil temperature at different depths, PAR, and wind speed). Preliminary results of this study show that soil temperature was a major factor responsible for the diurnal pattern of methane release. In fact the increase in soil temperature during midday, following the increase in solar radiation, lead to an increase in methane production and methane diffusion through the soil, as also observed by Svensson and Rosswall (1984). The increase in wind speed during daytime could also have lead to a "pumping effect", and to an increase of methane release from the soil.

However, due to co-linearity of these and other processes, it is difficult to separate them at this stage, and to estimate relative importance of each of the key variables in explaining methane flux. Presently, models describing methane flux as a function of wind speed, PAR or soil temperature yield similar r-square values. A factorial experiment would now be required to separate contributions of each of these variables, and to allow better understanding of the processes of methane release.

Acknowledgements

Authors deeply appreciate help and support provided by Barrow Arctic Science Consortium (BASC), National Science Foundation (NSF), and everyone involved in measurements, logistics and maintenance of the experimental field sites at BEO.

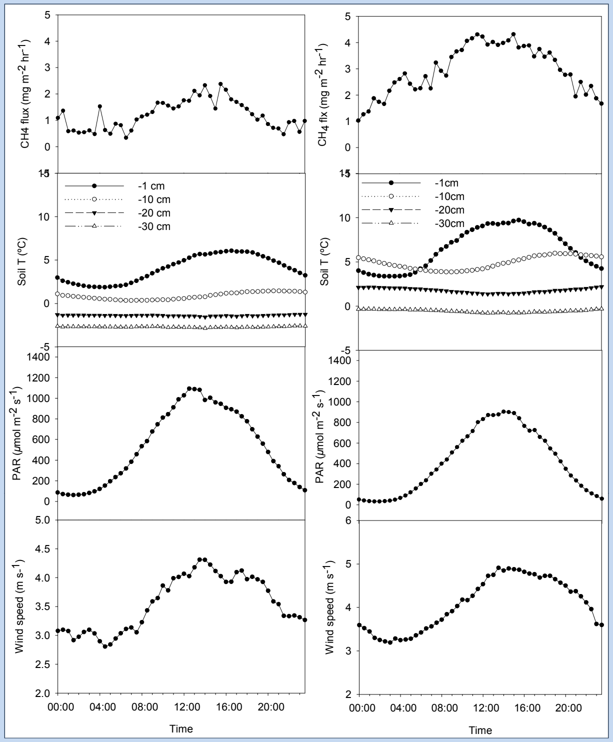

Figure 3. Monthly average of CH_4 fluxes, soil temperatures at -1, -10, -30 cm depths, PAR, and wind speed for June (left side) and July (right side) of 2006.

Bibliography

Aubinet M, A Grelle, A Ibrom, U Rannik, J Moncrieff, *et al.* 2000. Estimates of annual net carbon and water exchange of European forests: the EUROFLUX Methodology. *Advances of Ecological Research:* 113-174

Svensson, BH, and T Rosswall. 1984. In situ methane production from acid peat in plant communities with different moisture regimes. *Oikos* , 43: 341–350

Verma S, F Ullman, D Billesbach, R Clement, and J Kim. 1992. Eddy-correlation measurements of methane flux in a northern peatland ecosystem. *Boundary-layer Meteorology,* 58: 289-304