Methane emissions from the Arctic Coastal Plain in Alaska

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Introduction

Methane is an effective greenhouse gas that has a warming potential about 23 times more than carbon dioxide, for a 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.

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 CH4 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 CO2, H2O, and sonic temperature, demonstrating that the TBI measured fluctuations in CH4 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).

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.

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Bibliography

