Expanding Spatial and Temporal Coverage of Arctic CH$_4$ and CO$_2$ Fluxes

Patrick Murphy*, Walter Oechel, Virginie Moreaux, Salvatore Losacco, Donatella Zona

Introduction

Measuring carbon fluxes in the Arctic is not an easy task, but it is a crucial part of understanding how significant this biome is to contributing to global climate processes. The purpose of this study is to augment current CH$_4$ and CO$_2$ flux measurements by utilizing new technology and new techniques. Over the course of three years, we expect to have reliable data that will point us towards an annual budget for both CH$_4$ and CO$_2$. In addition to contributing to historical datasets of carbon exchange in the Arctic, this data – especially the CH$_4$ fluxes – will be helpful to modifying and strengthening models of future carbon exchange.

In order to implement year-round measurements of CH$_4$ and CO$_2$ fluxes, it was necessary to fabricate a new tower system. This system had to be designed to withstand the exceptional winter conditions in Northern Alaska, account for redundant equipment, provide reliable data acquisition, and still be cost-effective enough to allow for five installations in sites with a varying availability of resources.

As we set about planning to install the new equipment, one thing became obvious to us: the LGR, along with other ancillary instruments and accessories, were not designed to be weather-proof. Temperatures on the North Slope of Alaska vary widely between -50°C and 20°C, snowfall can reach 100cm in a year, and wind speeds are regularly as high as 20ms$^{-1}$. Because we expected to continue measurements even during extreme conditions, the instruments needed to be housed in a steady environment that could be regulated regardless of external conditions.

The Iowa Rotoplastics Grizzly Coolers were chosen for their ability to withstand damage from bears and other wildlife, as well as their exceptional insulation. We decided to separate the LGR FGGA's external pump from the instruments to prevent vibrations from contributing noise to the 10Hz data. It was necessary to modify the coolers to control the internal temperature. The following was done to each box:

- One hole was drilled to provide access for cables and gas lines.
- Two holes were drilled to allow ventilation when needed. The air intake hole featured a vent facing down to prevent snow from entering, while the exhaust featured a flap that remains closed when no air is flowing. Both holes were secured with nets to prevent moisture from entering.
- Redundant fans were controlled by both a temperature sensing program in the data logger and a common household thermostat.
- Two 90W heaters were installed in each large box. Most of the year, the LGR and external pump both provide enough heat to maintain their respective boxes within the operating temperature range.
- The boxes were raised at least 1m above the tundra to prevent snow drifts from forming around the tower.

Until now, the temperatures within the Grizzly boxes have been maintained very consistently. We have noticed an occasional drop in pressure in the LGR. We are not sure what causes this, although it may be a result of the direction the wind and/or a restriction in the intake pipe. The data become noisy as the pressure moves away from 140 torr, something the manufacturer has specifically emphasized. We are still troubleshooting these and similar problems as they arise.

Box Design

A critical component of the eddy covariance technique is the measurement of three-dimensional wind speed and direction (u, v, w), as well as the sonic temperature (Ts). Eddy covariance data are susceptible to noise and gaps when the sonic anemometer's transducers are blocked by ice and snow. Our solution to combat this is to use a heated sonic anemometer. This prevents ice and rims from forming over the instrument. This ensures that data collection can continue during the harsh Arctic winter.

Anemometer Heating

The first several months of this multi-year study have presented our group with many challenges and successes. As a result of very hard work from everyone, all seven of our eddy covariance towers in Alaska are working. Five of these include new equipment, the remaining two are not presented here. As winter progresses and 2014 begins, we expect to continue collecting reliable fluxes for both CO$_2$ and CH$_4$. Some notes and accomplishments:

- To continue reliable methane flux measurements through winter, we used new closed-path instruments installed within a dedicated, temperature-controlled enclosure.
- To avoid large data gaps, our group developed a system to heat a sonic anemometer and melt ice.
- While difficult, it is possible to continue measurements of methane and carbon dioxide fluxes through winter in northern Alaska using these methods.
- For both methane and carbon dioxide, we have seen fewer and shorter gaps in data due to poor weather conditions.

Conclusion

The boxes were raised at least 1m above the tundra to prevent snow drifts from forming around the tower.