Measuring Carbon Dioxide Efflux From Arctic Environments During the Non-Growing Season

Em Paul
Department of Physics, Radford University, Radford, Virginia 24142

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Introduction

Soil decomposer microorganisms use the process of carbon (C) mineralization to convert organic C to carbon dioxide (CO_2). Soil surface CO_2 efflux is the measure of CO_2 continuously emitted from soil due to C mineralization and can be used to measure soil health and the effects of climate change. Efflux in vulnerable environments such as beach ridge ecosystems in Utqiaġvik, Alaska remains unknown.

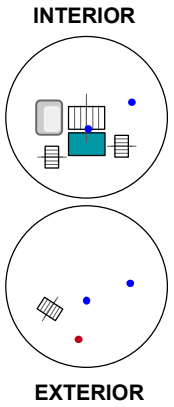
Goals and Methods

Samples consisted of 15 minutes of data collection. Several locations were selected off the coast of Utqiaġvik, Alaska between February 25 and March 1, 2024 during the non-growing season. Data were collected over sea ice with and without snow cover within 0.5 km from the shore (71.329°N, 156.681°W). Measurements were adjusted to give a baseline of the recorded ambient CO_2 concentration (US Department of Commerce, 2005).

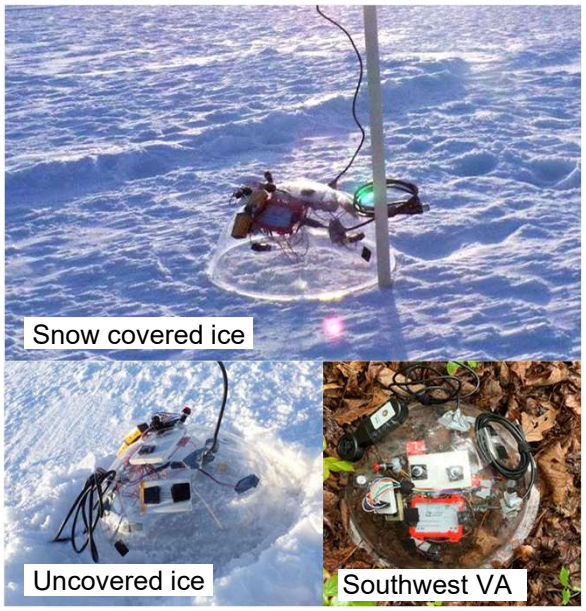
Additional samples were collected with the same data collection methodology in Blacksburg, VA on the border of Jefferson National Forest. The data were analyzed within the context of daily total precipitation (US Department of Commerce, 2024).

Component Schematics

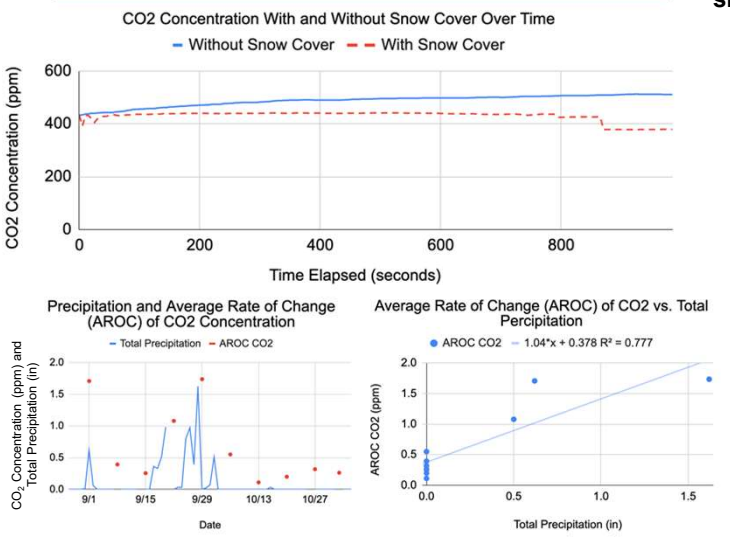
- Breadboard (CO_2, temperature, and pressure sensors, anemometer)
- Arduino microcontroller
- Breadboard (button, status LED, OpenLog)
- Rechargeable lithium 9V battery
- Button to start data collection
- Breadboard (5V voltage regulator)
- Wire opening



Data Collection



Results



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Communication Theory & Importance

The results indicate that there is a significant (p-value < 0.001) difference between CO_2 concentration in samples with and without snow cover. The CO_2 concentration of samples without snow cover was on average 58 ppm higher than in samples with snow cover. The decreasing snow cover as a result of global warming and indication of increased CO_2 efflux under decreased snow cover shows a positive feedback mechanism of global warming. Efflux rates should be further explored over more ecosystems to holistically understand C budgets.

Data collected in southwest Virginia was associated with a strong positive correlation ($R^2 = 0.777$) between CO_2 efflux and precipitation. This suggests evidence of increased soil bacterial net productivity with increased precipitation, however other factors may also influence CO_2 efflux. Changes in precipitation as a function of climate change could cause fluctuations of CO_2 efflux and therefore changes in global surface temperatures. More longitudinal studies in a variety of environments, specifically investigating microbial net productivity should be conducted.

References

US Department of Commerce, N. (2024, July 30). Climate. National Weather Service. https://www.weather.gov/wrh/climate.

US Department of Commerce, NOAA. "Global Monitoring Laboratory - Carbon Cycle Greenhouse Gases." GML, 1 Oct. 2005, gml.noaa.gov/ccgg/data/co2.html.

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