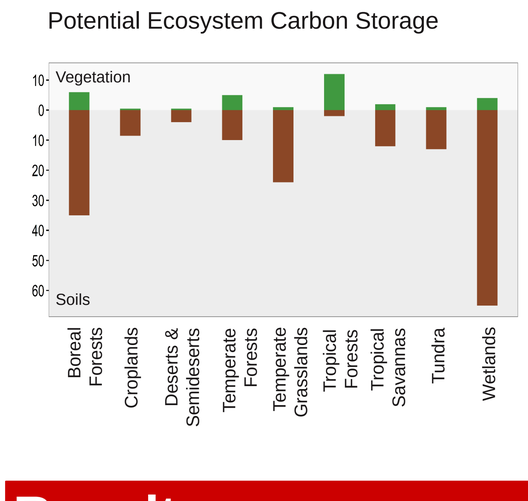
Developing indicators of CO_2 flux from Arctic wetlands

Megan Amanatides[1] & Erin Lee Hestir[1]
[1]North Carolina State University, Raleigh, USA
Department of Marine, Earth and Atmospheric Science | Center for Geospatial Analytics

Introduction & Background

There is large uncertainty about how carbon in Arctic wetlands will respond to climate change [*ACIA,* 2004; *Schuur et al.,* 2015]. Understanding changes in CO_2 flux and its potential drivers is a crucial first step towards determining how Arctic wetland carbon balance will change with climate change. This study synthesizes micrometeorological data from across the Arctic to address the following research questions:

1. **How is CO_2 flux changing in Arctic wetlands?**
2. **How are the potential drivers of CO_2 flux changing in Arctic wetlands?**



Wetlands serve as an important sink in the global carbon cycle. Unfortunately, wetlands are more vulnerable to climate change than other ecosystems [*Erwin,* 2008], and as our climate continues to warm, northern latitudes are expected to experience the bulk of the warming [*IPCC,* 2007].

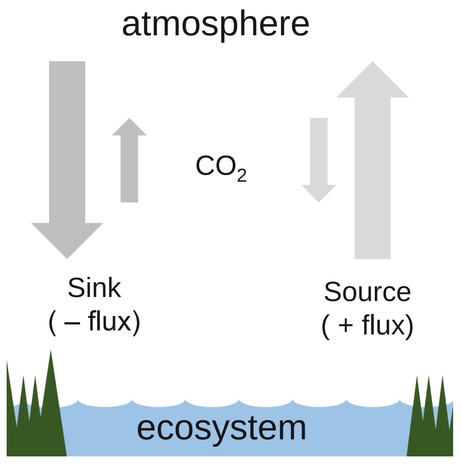
(Left) Carbon storage in vegetation and soils. Wetlands play a disproportionate role in carbon storage relative to other ecosystems

Conceptual Model

Warmer and drier Arctic conditions can diminish the productivity of Arctic wetland vegetation as shown in the figure on the left. This could potentially cause the wetland to shift from a sink to a source of atmospheric CO_2.

I hypothesize that variations in CO_2 flux can be explained by meteorological variables including:

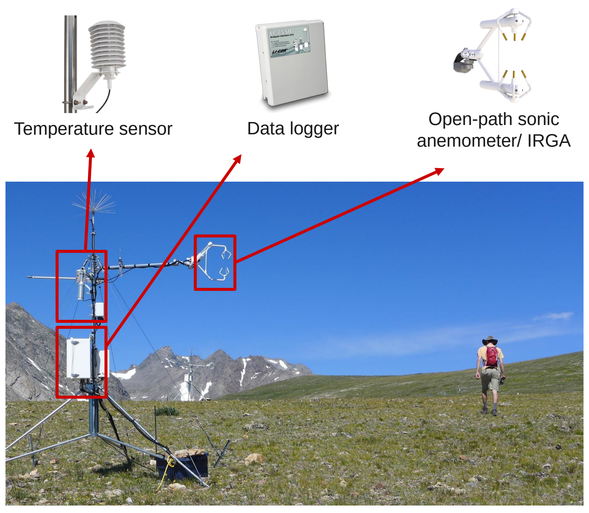
- Temperature
- VPD (Vapor Pressure Deficit)
- Precipitation
- Shortwave radiation
- Evapotranspiration



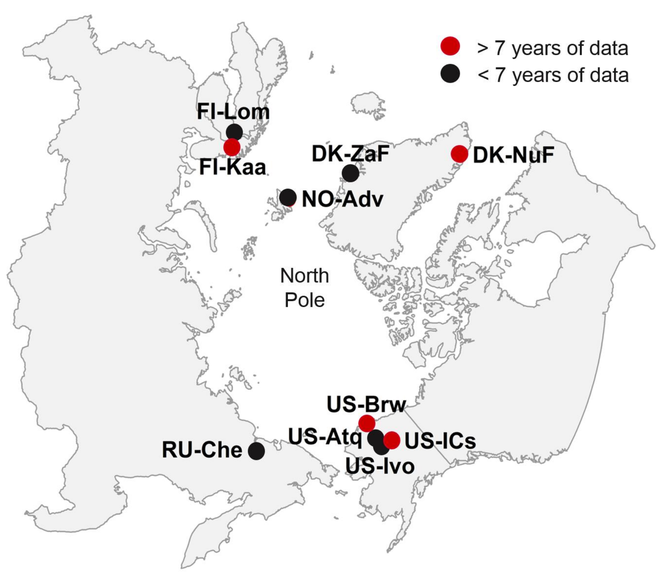
Currently, Arctic wetlands act as a sink for CO_2. However, two potential ecosystem responses to climate change include the wetland becoming a greater sink for CO_2 or the wetland shifting from a sink to a source of CO_2.

Methods

Study Sites



Instrumentation at each micrometeorological flux tower (above) located at each study site (right) takes near continuous measurements of CO_2 flux and various meteorological variables.



Analysis

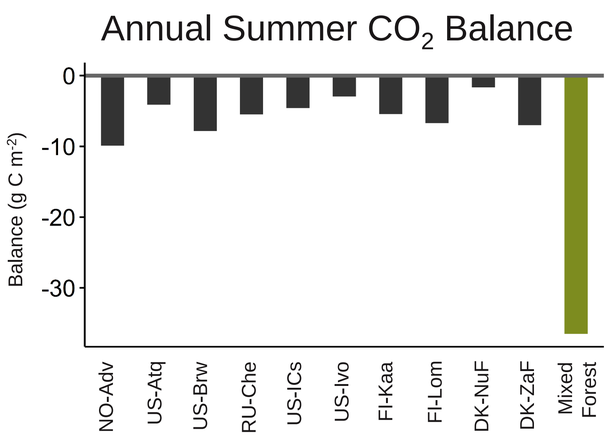
Gaps in flux tower data can occur from either instrument outages or the quality control process. Before analysis, data were gapfilled [*Reichstein et al.*, 2005]. Trends in CO_2 flux and meteorological variables were tested at sites with at least 7 years of data

- Trend test – Mann Kendall [*Mann*, 1945]
- Magnitude of trend – Sen slope [*Sen,* 1968]

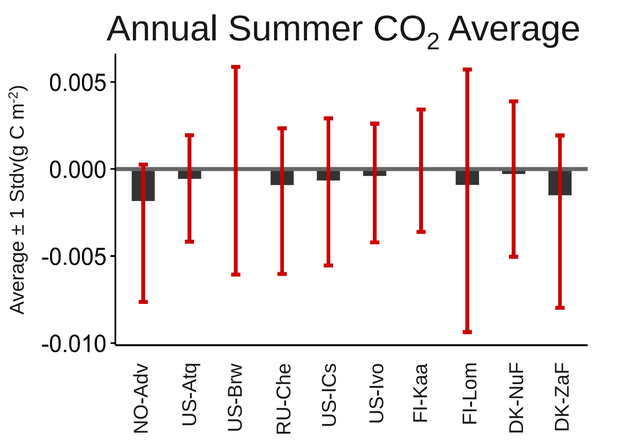
(Right) Time series of summer CO_2 flux data from each site that has at least 7 years of data. Green points represent a positive CO_2 flux (source) while the blue points represent a negative CO_2 flux (sink).

Results

CO_2 flux across study sites

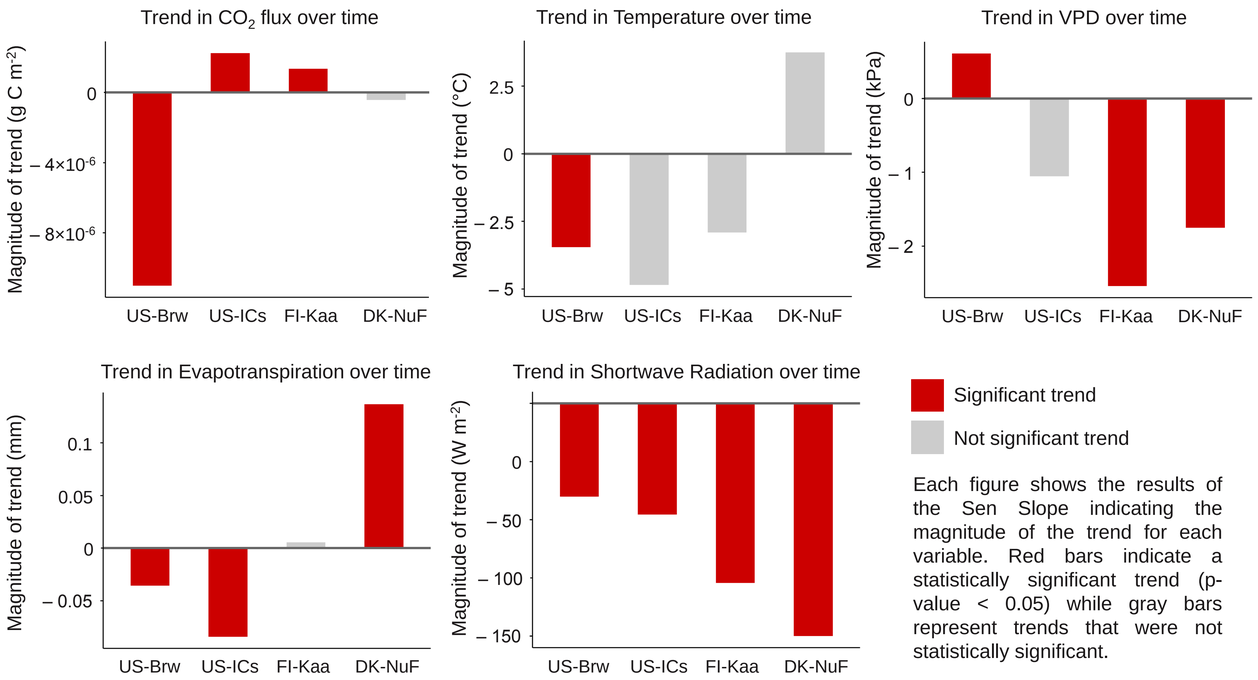


Currently, Arctic wetlands are a CO_2 sink, though they are not storing as much carbon as many mixed forest ecosystems around the globe.



Although Arctic wetlands are acting as a CO_2 sink, the standard deviation associated with each site indicates that they could potentially act as either a sink or a source.

Trends in CO_2 flux and meteorological variables



Each figure shows the results of the Sen Slope indicating the magnitude of the trend for each variable. Red bars indicate a statistically significant trend (p-value < 0.05) while gray bars represent trends that were not statistically significant.

Conclusions & Future work

Conclusions

- All 10 sites act as a sink for CO_2 during the summer
- 3 of 4 sites show a statistically significant trend in CO_2 flux over time
  - 2 of these 3 sites show increasing CO_2 flux (potential future source)
  - 1 of these 3 sites shows decreasing CO_2 flux over time (potential sink)
- Most meteorological variables show strong site to site variability

Future work

- Modeling to understand meteorological variables as drivers of CO_2 flux
- Predict future CO2 flux as with changes in climate

References

ACIA (2004), Impacts of a Warming Arctic. *Arctic Climate Impact Assessment – Synthesis Report*. Cambridge Univ. Press, NY , NY.
Erwin, K. L. (2008). Wetlands and global climate change: the role of wetland restoration in a changing world. *Wetlands Ecol. and Management*, 17, 71-84
IPCC (2007). Climate Change: Synthesis Report. *Fourth Assess. Report of the Intergov. Panel on Climate Change.* Cambridge Univ. Press, NY, NY
Mann, H. B. (1945). Nonparametric tests against trend. *Econometrica,* 13, 163-171
Mu, et al. (2011). Improvements to a MODIS global terrestrial evapotranspiration algorithm. *Remote Sensing of Environment*, 115, 1781-1800
Reichstein et al. (2005). On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm. *Glob. Change Biol.,* 11, 1424-1439
Schuur et al. (2015), Climate change and the permafrost carbon feedback, *Nature,* 520, 171-179
Sen, P. K. (1968). Estimates of the regression coefficient based on Kendall's tau. *Journal of the American Statistical Association*, 63, 1379-1389