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
Contact: mmamanat@ncsu.edu

Paper Number: B11C-0462

Introduction & Background

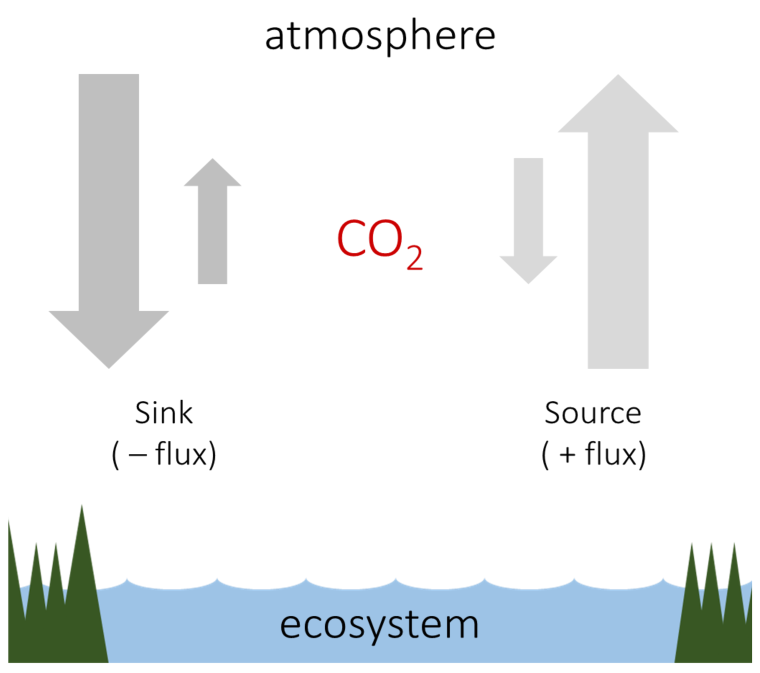
Motivation

Wetlands serve as an important sink in the global carbon cycle. Unfortunately, Arctic wetland ecosystems are more vulnerable to climate change than other ecosystems [*IPCC*, 2007; *Erwin*, 2008]. It is uncertain 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 step towards determining how Arctic wetland carbon balance will change with climate change. This study synthesizes micrometeorological data from across the Arctic to investigate:

1. How are the potential drivers of CO_2 flux changing in Arctic wetlands?
2. Which potential drivers best indicate changes in CO_2 flux in Arctic wetlands?

Figure 1: 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.

Conceptual Model



I hypothesize that CO_2 flux can be explained by a combination of meteorological variables including:

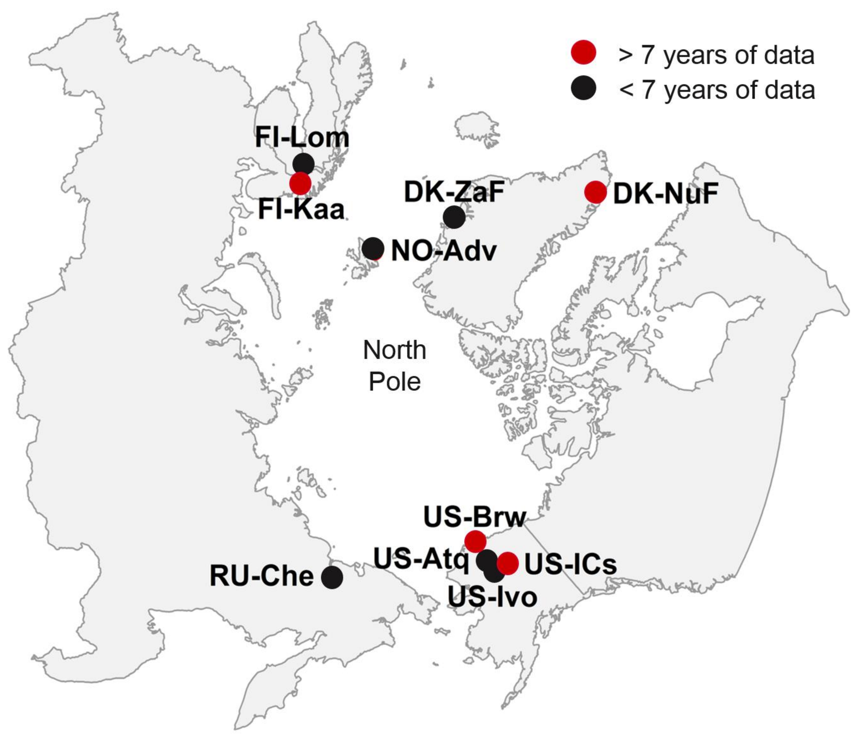
- Temperature
- VPD (Vapor Pressure Deficit)
- Precipitation
- Incoming shortwave radiation
- Evapotranspiration
- Wind speed and direction

Figure 2: 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

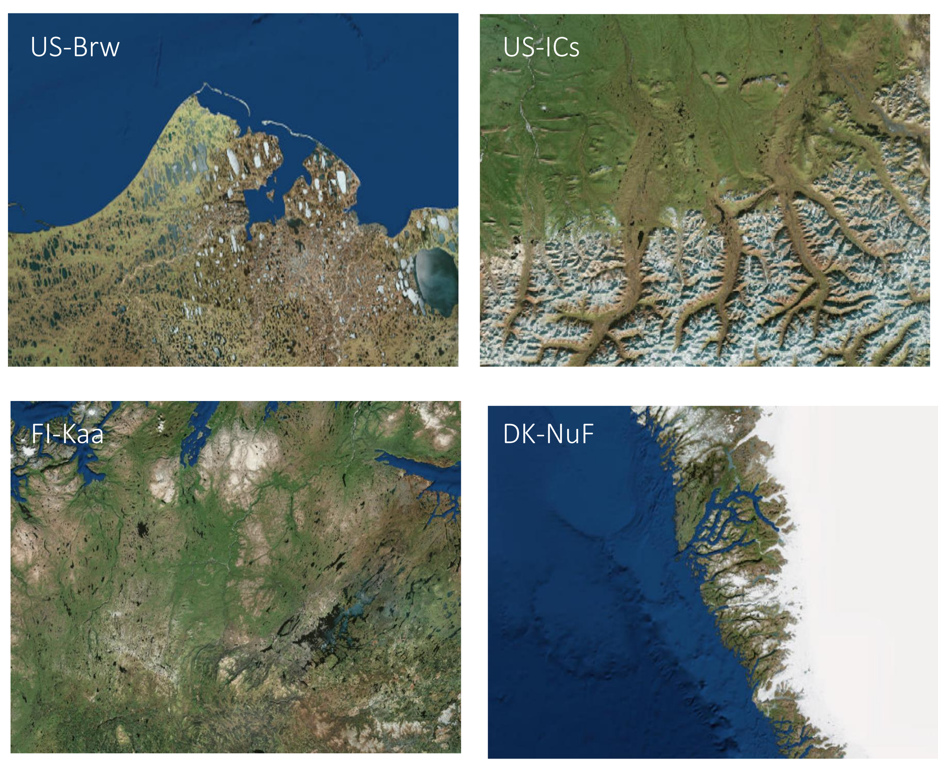
Study Sites

Figure 3: Each study site (right) is equipped with a micrometeorological flux tower (above). Each tower takes near continuous measurements of CO_2 flux and various meteorological variables. Only data from the summer months were analyzed in this study.



Analysis

Gaps in flux tower data can occur from either instrument failure or the quality control process. Before analysis, data were gapfilled [*Reichstein et al.*, 2005]. At sites with at least 7 years of data, potential covariation between CO_2 flux and meteorological variables was investigated. At all sites, CO_2 balance was calculated and a PCA was performed on the data before using a Random forest to determine variable importance [*Breiman*, 2001].



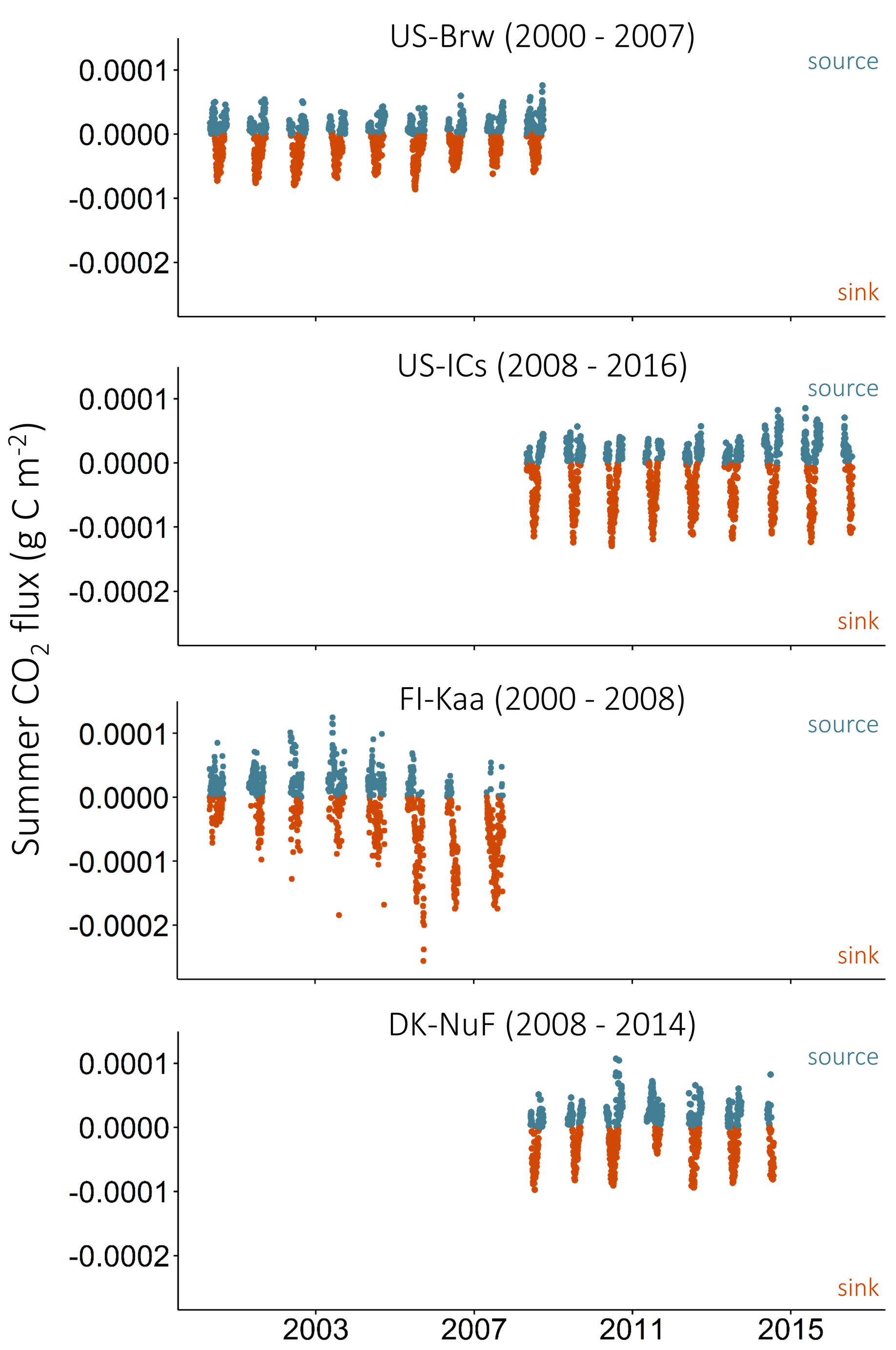
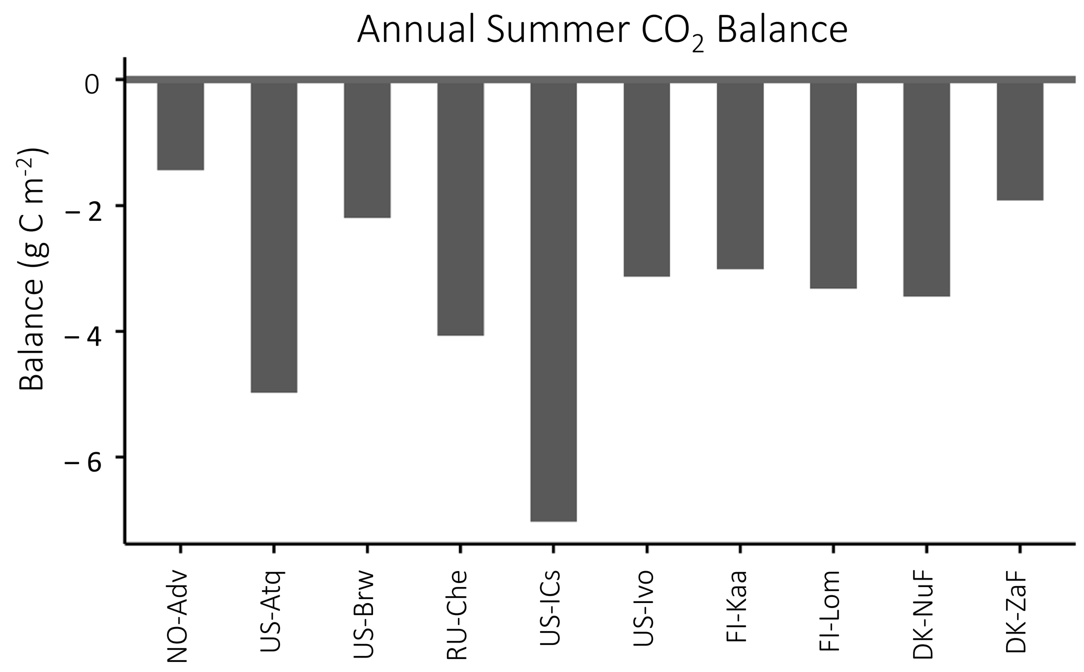


Figure 4: Sites with at least seven years of data are shown with satellite imagery (left) and as a time series of CO_2 flux (above). Teal and orange points show positive (source) and negative CO_2 flux (sink), respectively.

Results

CO_2 flux across study sites



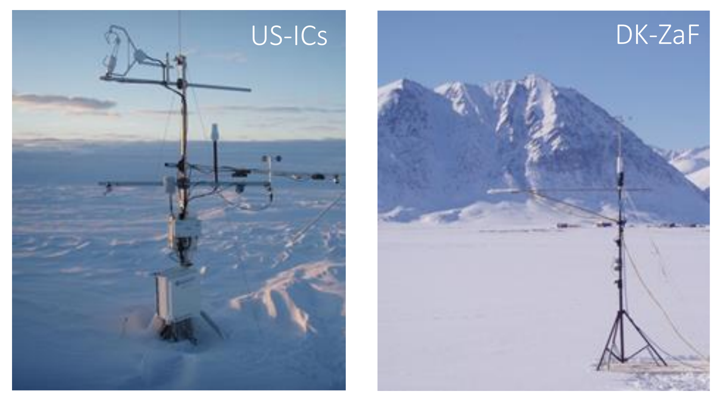


Figure 5: Each study site currently acts as a sink for atmospheric CO_2 although there is large site-to-site variability in the strength of the sink (left). For example, US-ICs (above, left) has the largest annual summer CO_2 balance while DK-ZaF (above, right) has one of the smallest annual summer CO_2 balances.

Covariation between CO_2 flux and meteorological variables

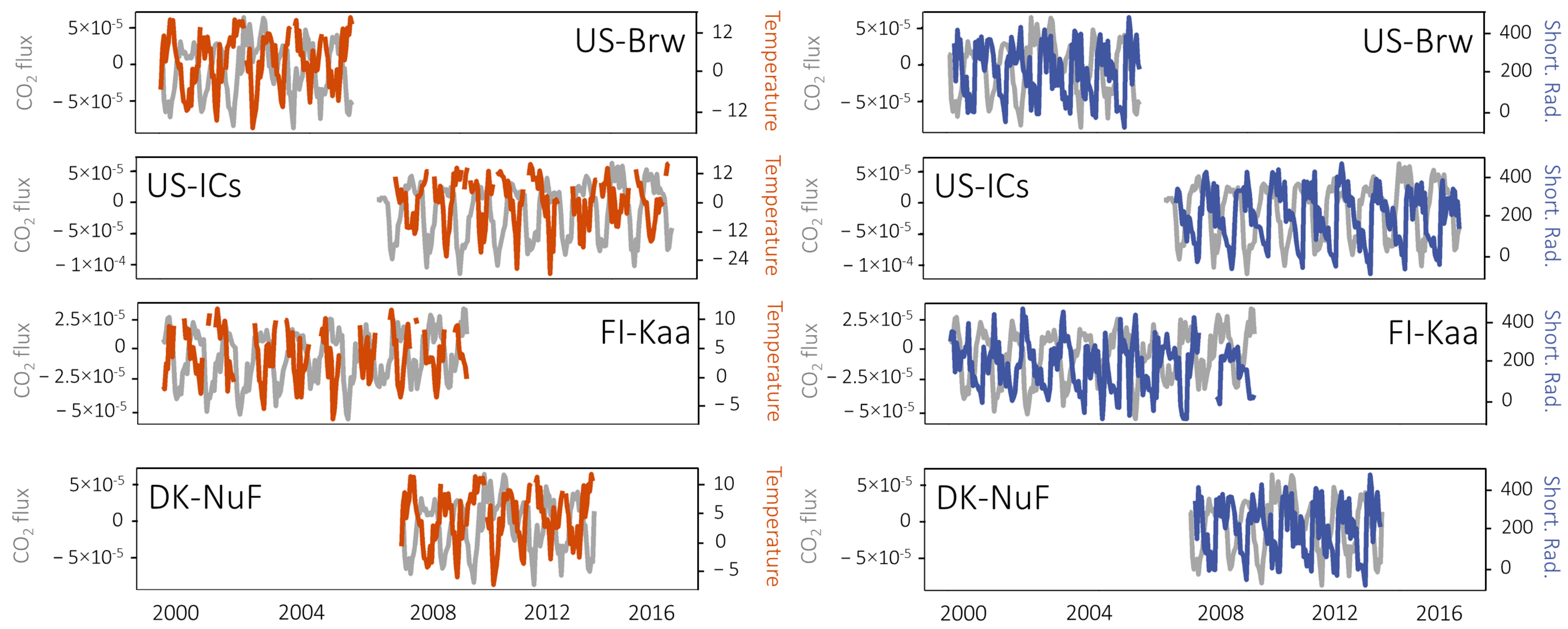


Figure 6: Weekly aggregated CO_2 flux, temperature, and shortwave radiation at sites with at least 7 years of data show potential covariation at times.

Variable Importance

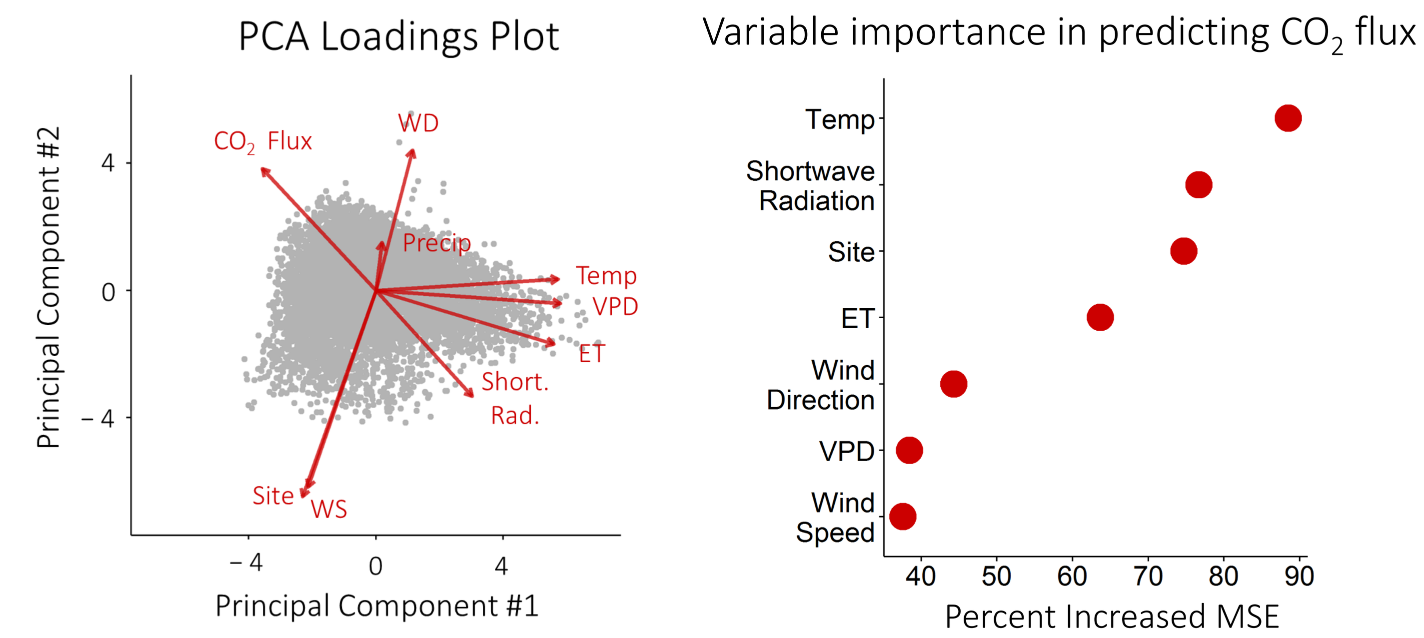


Figure 7: PCA results (left) indicate the potential relationships between different variables. Random forest results (right) indicate that tempeture and shortwave radiation have the largest influence on CO_2 flux.

Conclusions & Future work

Conclusions

- All 10 sites act as a sink for CO_2 during the summer
- 2 of 4 sites show increasing CO_2 flux; 1 of 4 sites show decreasing CO_2 flux
- Most meteorological variables show strong site-to-site variability
- Temperature, shortwave radiation, and site location have largest influence on CO_2 flux

Future work

- Investigate changes in vegetation at each site
- Predict future CO_2 flux as with changes in climate

Acknowledgements

We acknowledge several AmeriFlux sites for their data: US-Brw & US-Ivo, several Euroflux sites for their data: NO-Adv, FI-Kaa, FI-Lom, DK-NuF & DK-ZaF, one FLUXNET sites for its data: US-Atq, and one AON site for its data: US-Ics. Funding for AmeriFlux data resources was provided by the U.S. Department of Energy's Office of Science. We thank F. Anderson, C. Edgar, D. Zona, D. Baldocchi, K. T. Paw U, N. Pirk, M. Lund, A. Noormets, and D. Cook for valuable advice and input.

References

ACIA (2004). Impacts of a Warming Arctic. *Arctic Climate Impact Assessment – Synthesis Report*. Cambridge Univ. Press, NY , NY.
Breiman (2001). Random Forests. *Machine Learning, 45, 5-32*
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
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