Developing indicators of Carbon Dioxide flux from Arctic wetlands

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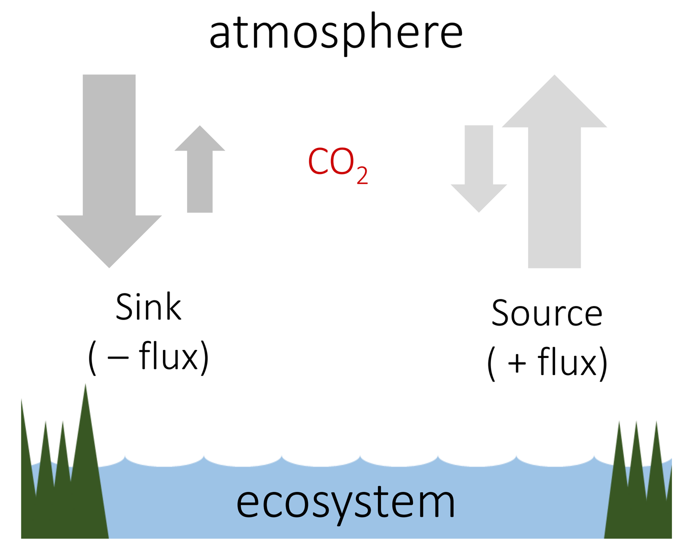
Introduction

Historically, Arctic wetlands have acted as strong sinks for atmospheric CO_2; however, it is uncertain how carbon in these ecosystems 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.

Warmer and drier Arctic conditions have the potential to diminish the productivity of Arctic wetland vegetation.

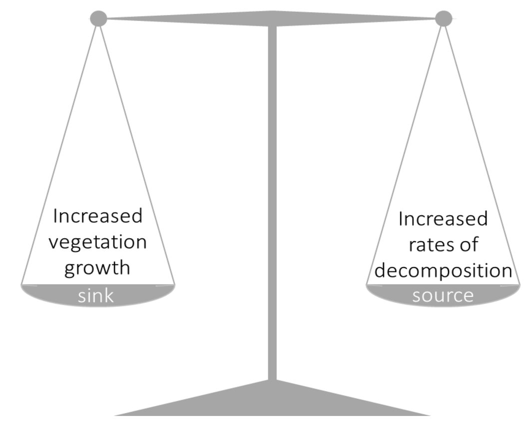


CO_2 flux is the exchange of CO_2 between the ecosystem and the atmosphere.

This study synthesizes micrometeorological data and satellite observations from 10 sites across the Arctic to investigate:

1. How is CO_2 flux changing in Arctic wetlands
2. What variables best indicate variations in CO_2 flux

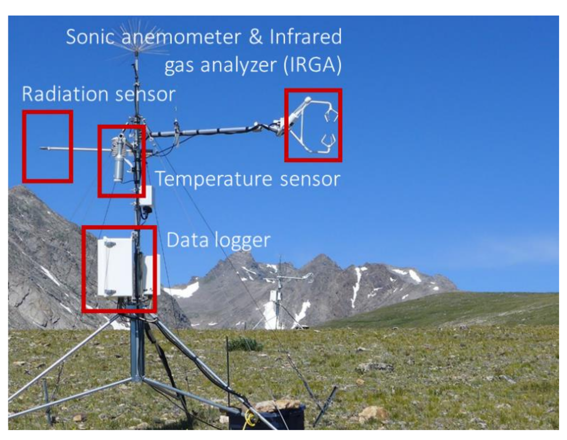
We hypothesize that with climate change, Arctic wetlands will become a greater sink for CO_2 because climate-induced changes that promote CO_2 sink activity (e.g. vegetation growth) will outweigh those that promote CO_2 source activity (e.g. increased decomposition).



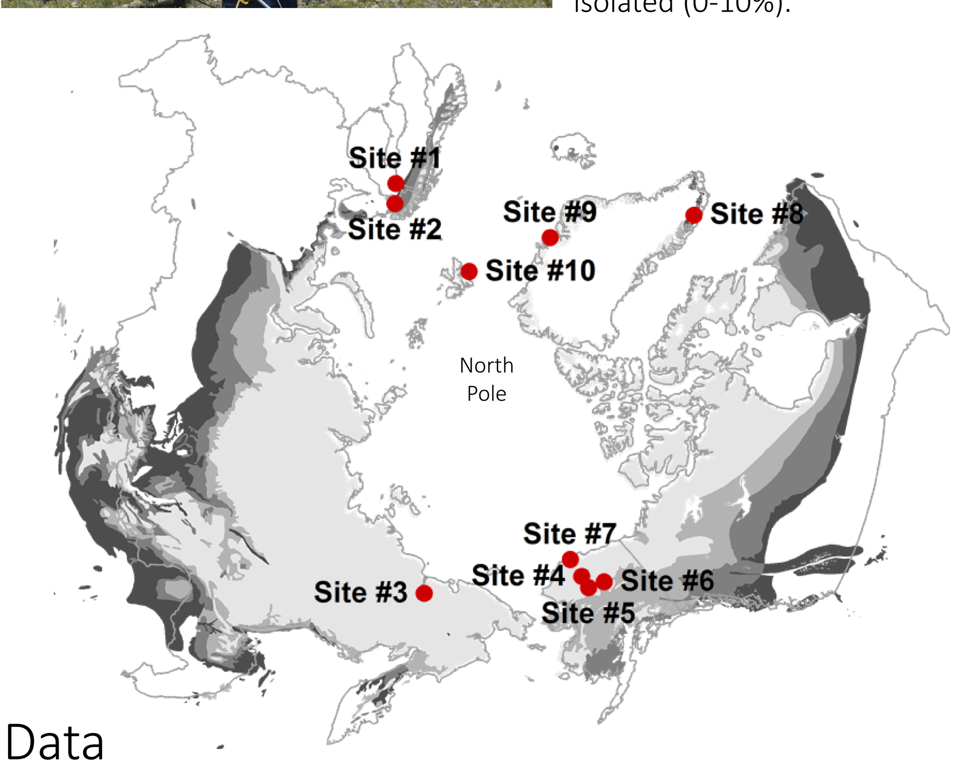
The CO_2 balance of Arctic wetlands will be determined by which process outweighs the other.

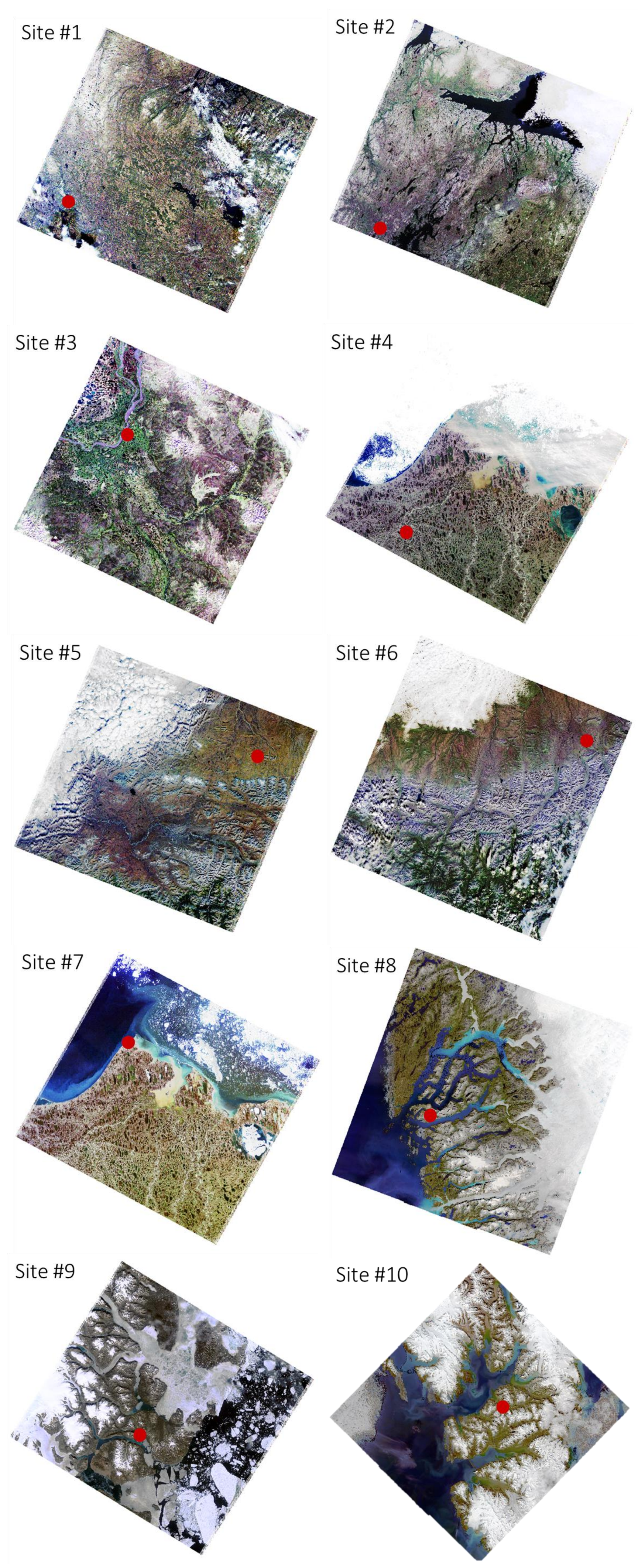
Methods

Study sites



Each study site (below) is equipped with a micrometeorological flux tower (left) which takes near continuous measurements of CO_2 flux and meteorological variables. Gray shading represents permafrost extent: continuous (90-100%), discontinuous (50-90%, sporadic (10-50%), and isolated (0-10%).





Data

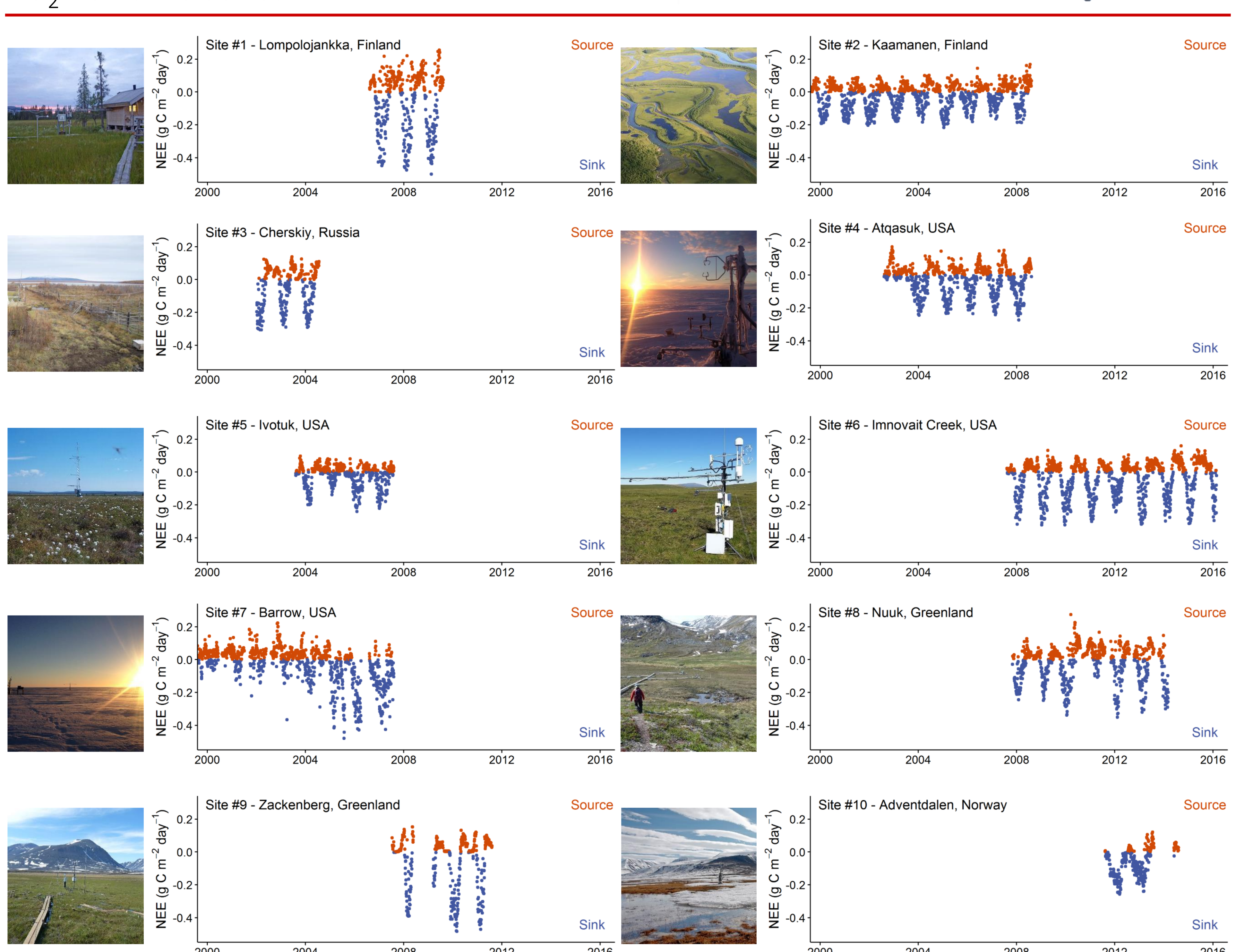
Summer (May – September) data was obtained from micrometeorological flux towers at each site:

- Air temperature
- Evapotranspiration (ET)
- Vapor pressure deficit (VPD)
- Solar radiation
- Wind speed
- Wind direction

Landscape variables was calculated from from Landsat (4-5, 7, 8) surface reflectance data:

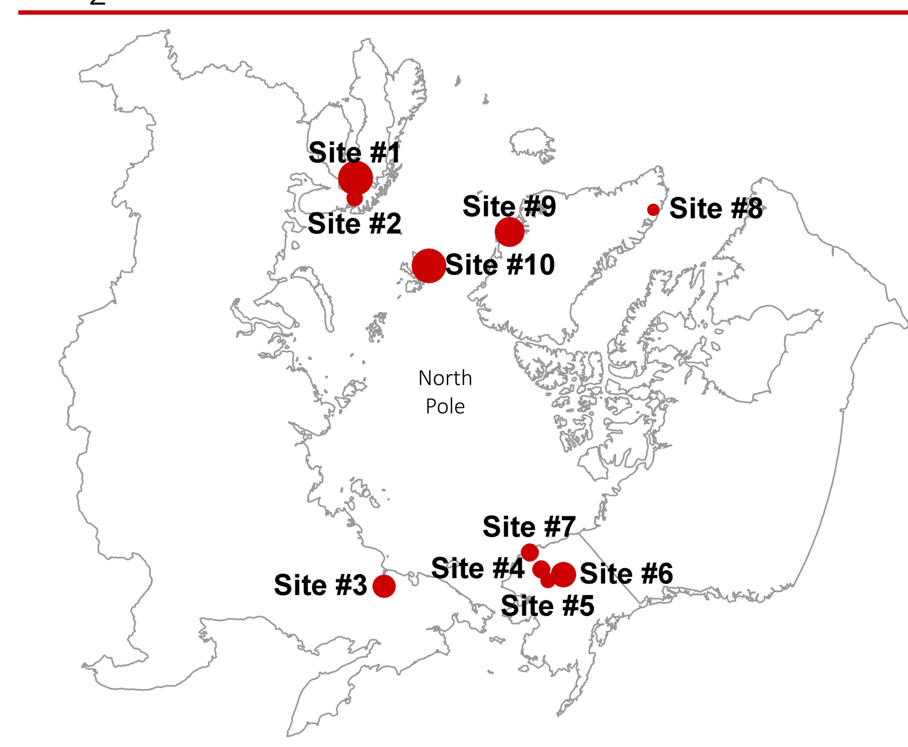
- Percent cover for snow, water, and land
- Normalized difference vegetation index (NDVI)
- Normalized difference moisture index (NDMI)

CO_2 flux time series

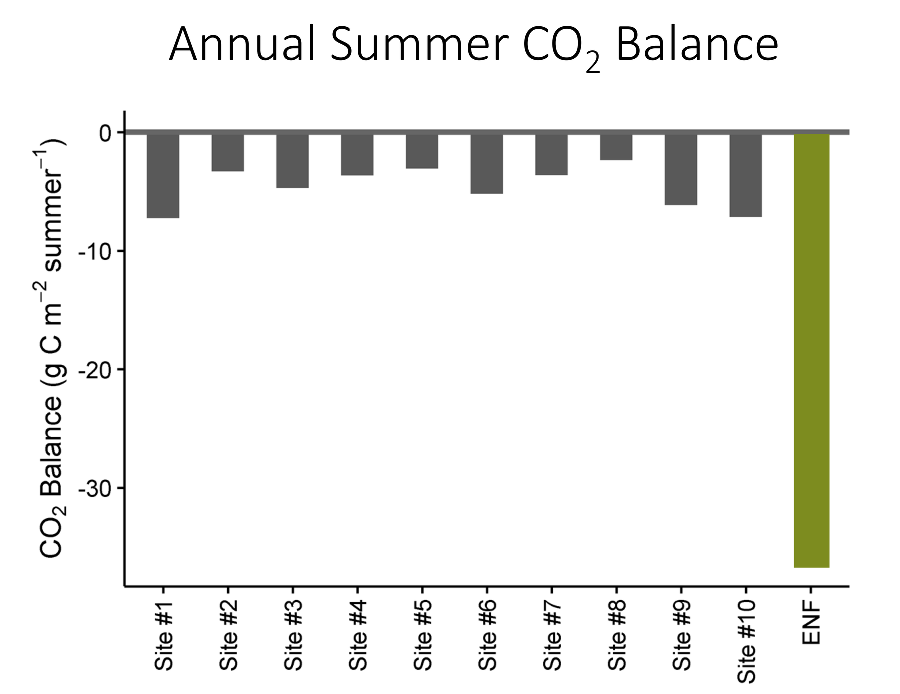


Results

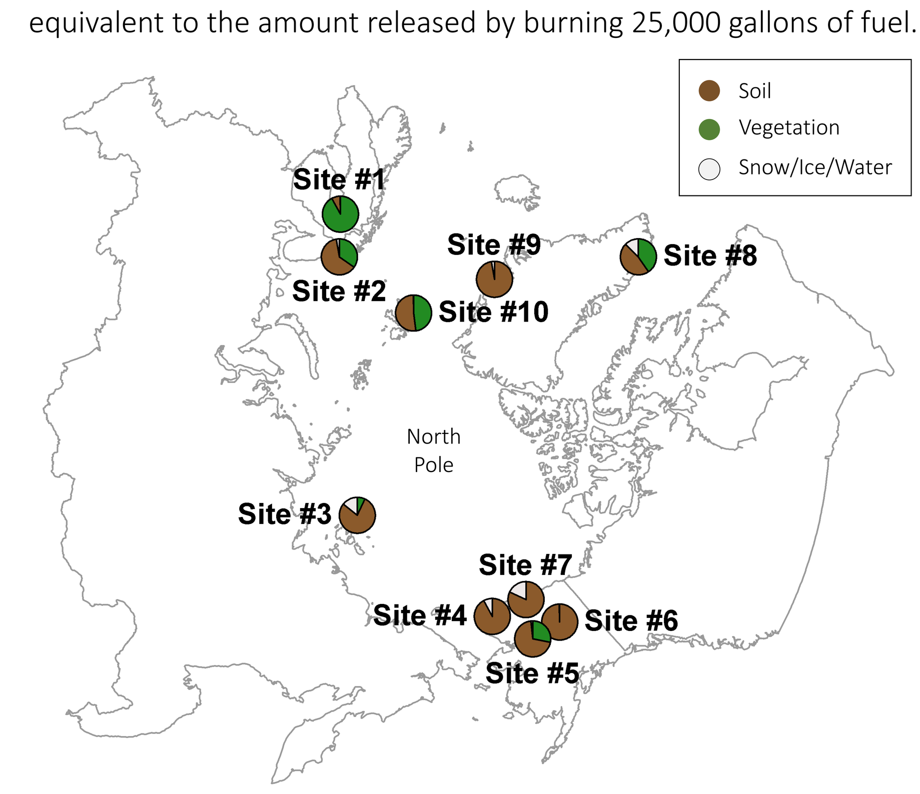
CO_2 balance and trends



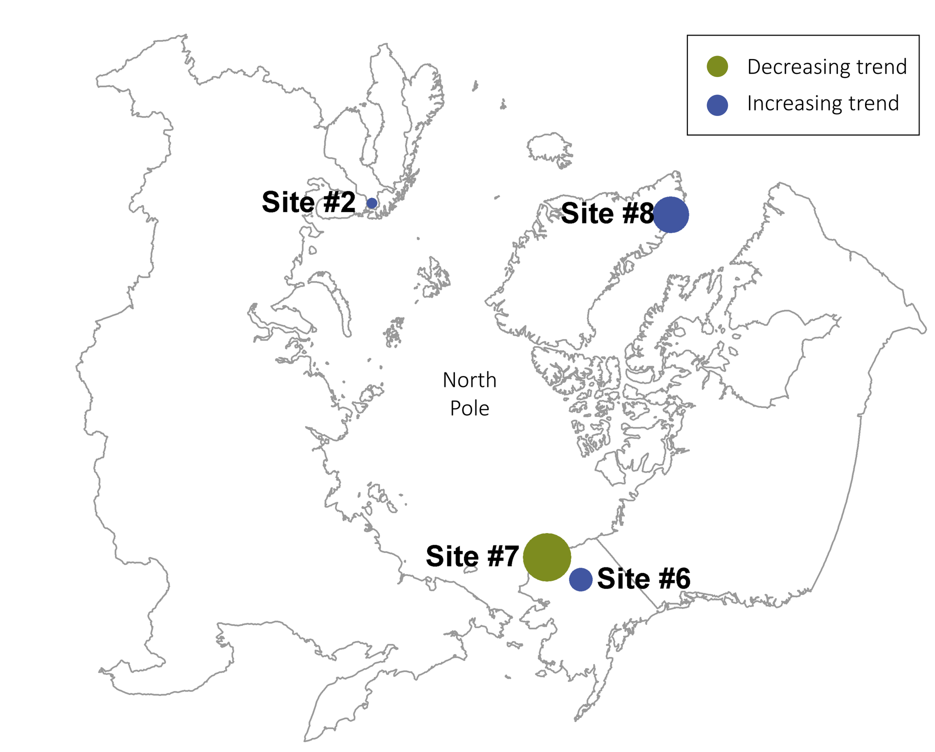
Annual summer CO_2 balance at each site. The size of the point denotes the strength of the CO_2 sink. Together, these ten sites sequester over 200 metric tons of carbon each summer; that's equivalent to the amount released by burning 25,000 gallons of fuel.



Currently, Arctic wetlands are an annual summer CO_2 sink, although they are not storing as much carbon as many mixed forest ecosystems are around the globe.

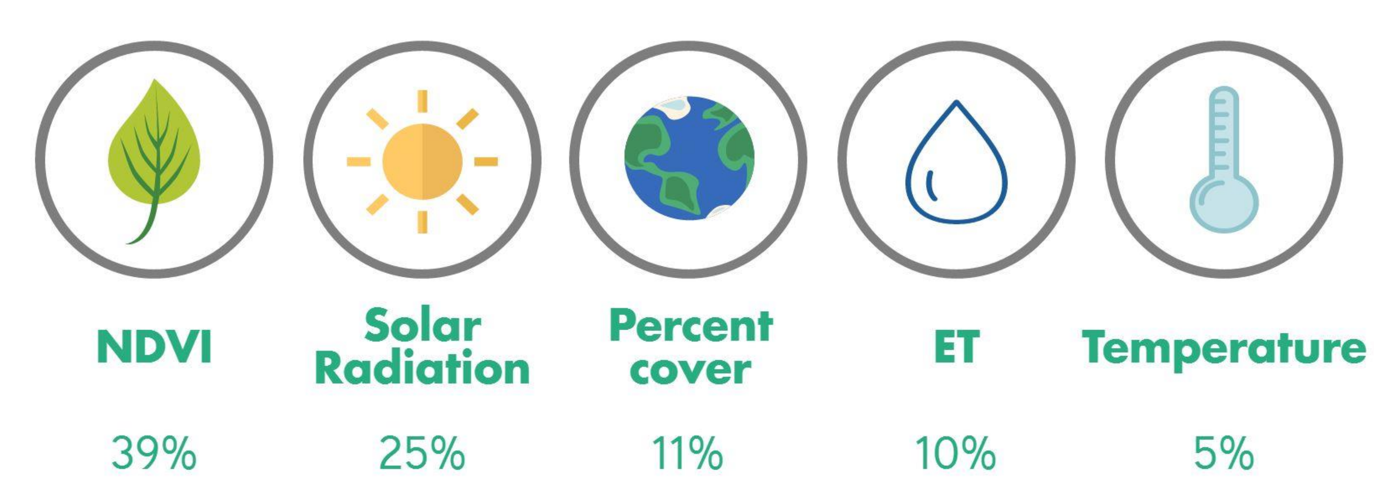


Average percent cover during the summer at each site. Percent cover was found using a combination of broadband spectral indices.



A trend analysis was performed at 4 of 10 sites that had ≥ 7 years of data. The nonparametric Mann-Kendall test for trend and Sen's slope were calculated [Sen, 1968; *Hirsh et al.*, 1982]. The size of the point represents the magnitude of the trend.

Indicators of CO_2 flux



Variable importance was assessed using a conditional inference forest [*Breiman*, 2001]. This analysis considered CO_2 flux as a function of both meteorological variables and landscape variables at 6 of 10 sites with sufficient flux tower and satellite observations.

Conclusions

CO_2 Balance and trends

- The effects of climate change are not uniform across Arctic wetlands
  - In some areas sink activity (vegetation growth) outweighs source activity (decomposition)
  - In others, source activity outweighs sink activity

Indicators of CO_2 flux

- CO_2 flux is most explained by changes in vegetation
- There was strong site-to-site variability

Acknowledgements

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