Molecules in a Living Landscape:

Soil Carbon and Vegetation Cover in a Greenland Mosaic

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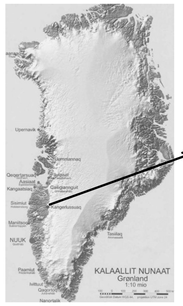
Introduction

Arctic soils hold an estimated 1672 gigatonnes of carbon--that is more than 2 times the amount of carbon in the atmosphere and half of all belowground organic carbon [1]. Soil carbon response to temperature is especially important in this region because low temperature systems are more sensitive to warming and rapid climate change is already being observed.

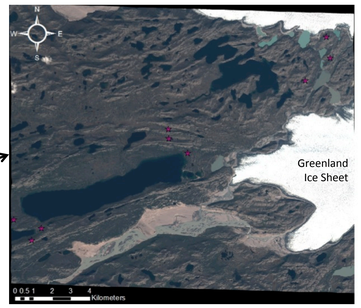
The variability of soil carbon storage and controls that determine the sensitivity to warming is not well understood [2]. This study uses a multi-scalar analysis to link aboveground heterogeneity of vegetation and temperature to belowground carbon storage in an tundra landscape in western Greenland.

Site Description

The study area is a low-Arctic tundra landscape located near Kangerlussuaq, Greenland. Mean annual daytime temperature is -0.6°C, with coldest daytime winter temperatures of -16.4°C in Feb and warmest summer averages of 16.3°C in July. Mean annual precipitation is 150 mm (Danish Meteorological Institute).



Map of Greenland



Satellite image of the study area

Methods

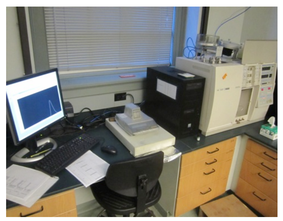
Land Cover Analysis

- Conducted a multistage ISODATA classification in ENVI
- Data: 1.34-m resolution multispectral WorldView2 satellite image, 10 July 2010, 18 km by 15 km area in the vicinity of Kangerlussuaq (above right)

Field Data and Sample Collection

- Selected 9 sites along a 20 km transect extending west from Russell Glacier
- Each site had four representative land cover patches (shrub, grass, mixed, soil deflation) and, when present, grass drainage
- Measured growing season air temp at 4-hour intervals with I-button temp loggers (Maxim, Inc), from 7/21 to 8/14
- Surface Samples: Between 8/08 and 8/13, we collected surface soil samples (0-5 cm) with a 2 cm diameter soil sampler from 6 randomly selected locations in each patch. Paired w/ each sample we:
  - Estimated plant % cover in a 0.5 m^2 quadrant
- Pit Samples: Sampled at 5-10 cm depth increments from 50 cm pits in ea. Patch; measured temperature with a thermistor probe at time of sampling

Collecting soil from a 50 cm pit



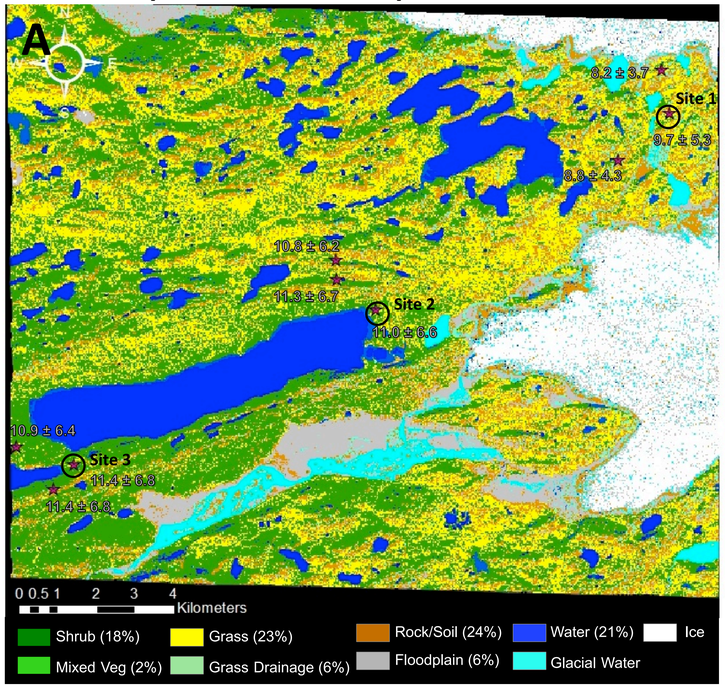
Elemental analyzer in the laboratory

Laboratory Analysis

- Analyzed soil organic carbon (SOC) with a Carlo Erba NA-1500 elemental analyzer.

How does soil carbon vary with vegetation cover and landscape position?

1. Landscape Cover and Temperature



Land Cover Classification Map

The study area has heterogeneous cover and was classified into five functionally distinct and detectable terrestrial cover types.

Air Temperature Pattern

Strong local air temperature gradient proximal to the ice edge during the growing season

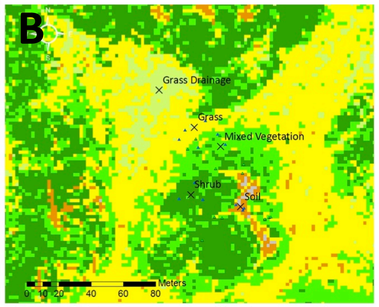


Figure 1. (A) Land cover classification map of the Kangerlussuaq area; stars mark the nine study sites; white numbers are mean growing season air temp (°C ± 1 SE). (B) High resolution map of Site 2; patches are labeled with the land cover type.

2. Soil Organic Carbon in Surface Samples

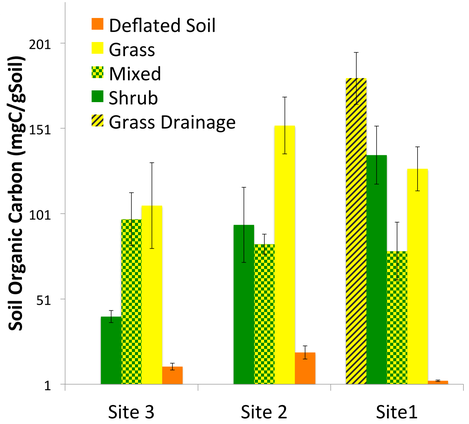
Soil organic carbon varies by vegetation type & landscape position

Vegetation type

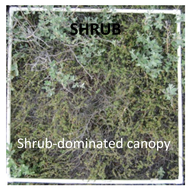
- Grass patches have high SOC
- Greatest SOC content found in the grass water track
- Deflation soil patches have reduced SOC

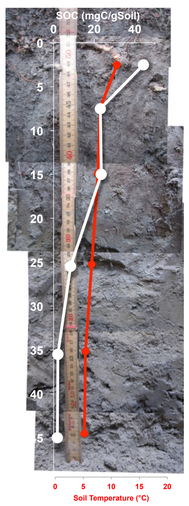
Landscape position

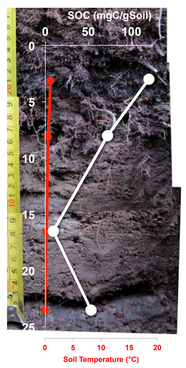
- Shrub SOC increases across the temperature gradient, with highest values at the cold site near the ice sheet

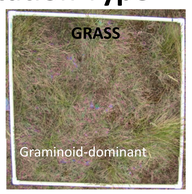


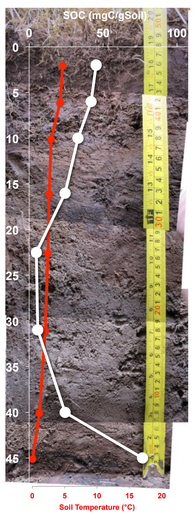
3. Soil Carbon Profiles by Vegetation Type

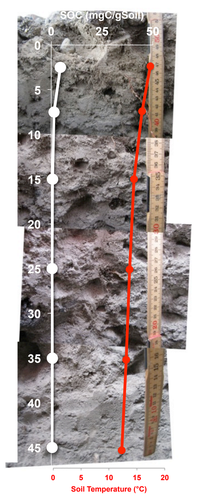












Soil Carbon at Depth

- Stores of carbon are found at depth
- Carbon peaks detected at the permafrost interface (e.g. Mixed Veg and Grass patches)

Soil Temp Pattern

- Soil temperatures vary by vegetation type
- Frozen ground was often within 50 cm (e.g. Mixed Veg & Grass)
- Minimally vegetated soil deflation have high soil temps

Future Research Directions

- Use laboratory and field-based manipulations to parameterize temperature sensitivity of soil respiration
- Test moisture control on temperature sensitivity of respiration
- Quantify landscape soil carbon stores from the spatial model
- Develop a Landsat-based model to apply the soil carbon model at a broader spatial and temporal extent

Discussion

- Variability of soil carbon stores could affect landscape-level carbon budgets and temperature sensitivity.
- Shifts in land cover vegetation types, such as shrub expansion from warming or soil and vegetation loss from wind deflation, can alter carbon processes.
- A long-term goal of this research is to develop a spatially explicit model of soil organic matter, soil respiration, and temperature sensitivity of soil carbon dynamics for western Greenland tundra ecosystems.
- Improved understanding of the biological feedback to global climate is relevant to Greenlandic decision makers as they guide national carbon, climate & environmental management policy.

Work Cited

[1] Tarnocai et al. 2009. *Global Biogeochemical Cycles*, **23**, GB2023. [2] von Lützow & Kögel-Knabner. 2009. *Biology and Fertility of Soils*, **46**, 1–15.

Acknowledgements

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